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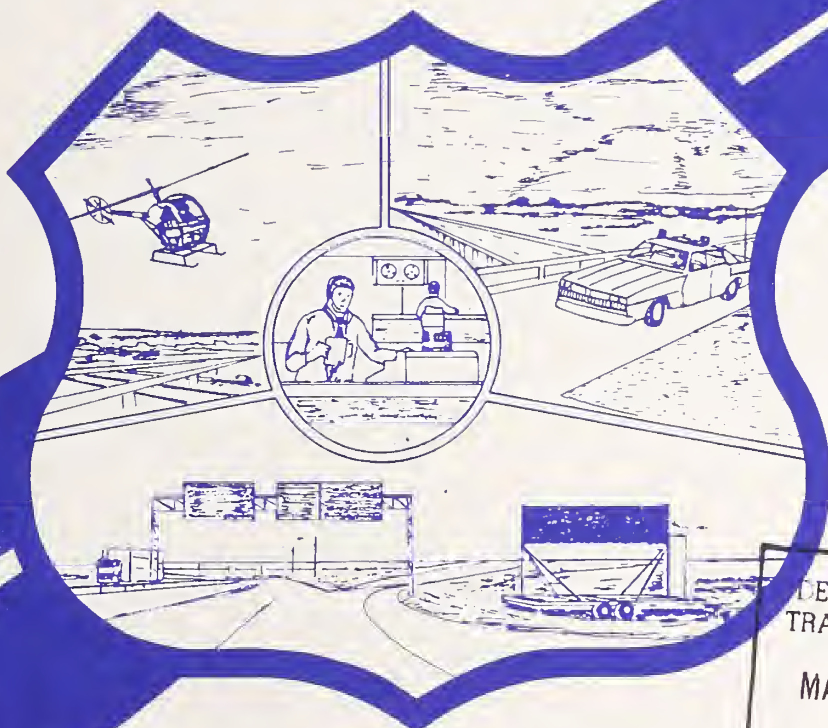
N ANTONIO MOTORIST INFORMATION AND DIVERSION SYSTEM

September 1981
Final Report



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U.S. Department of Transportation
Federal Highway Administration

Offices of Research & Development
Traffic Systems Division
Washington, D.C. 20590

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FOREWORD

This report presents the results of the second and final phase of contract DOT-FH-11-8505 "Human Factors Requirements for Real-Time Motorist Information Displays." It describes the effectiveness of a low-cost motorist information and diversion system in San Antonio, Texas.

The research was carried out by the Texas Transportation Institute. It consisted of the evaluation of several low cost diversion strategies. The report describes the hardware and operation of the system. The problems encountered and recommendations for future systems are also discussed.

Sufficient copies of the report are being distributed by FHWA Bulletin to provide a minimum of two copies to each FHWA regional office, one copy to each FHWA Division office and one copy to each State highway agency. Direct distribution is being made to the Division offices.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

NOTICE

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16. Abstract

This report documents studies to evaluate the effectiveness of a low-cost motorist information diversion system (MIDS) in San Antonio, Texas. The system was implemented in 1977 as a demonstration program by the Texas State Department of Highways and Public Transportation, working in cooperation with the San Antonio Corridor Management Team. Its purpose was to alleviate congestion and reduce accidents on I-35 in San Antonio near the Central Business District. It included the following phases:

1. I-35 route change around the CBD,
2. use of a low-cost changeable message sign (CMS) system for freeway diversion, and
3. use of the CMS system for managing traffic during freeway maintenance.

In addition to system effectiveness, the lessons learned from the demonstration program and recommendations for future urban MIDS systems are discussed.

17. Key Words
Motorist information displays, traffic diversion, changeable message signs, interstate route change, directional sign changes, traffic control in work zones, detours.

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PREFACE

This report is the culmination of Phase II of a research project entitled, "Human Factors Requirements for Real-Time Motorist Information Displays." Documentation of Phase I is presented in a seventeen-volume report entitled, Human Factors Requirements for Real-Time Motorist Information Displays. Titles of the Volumes are shown below.

Volume	FHWA-RD Number	Title
1	78- 5	Design Guide
2	78- 6	State of the Art: Messages and Displays in Freeway Corridors
3	78- 7	Summary of Systems in the United States
4	78- 8	Bibliography and Selected Annotations: Visual Systems
5	78- 9	Bibliography and Selected Annotations: Audio Systems
6	78-10	Questionnaire Survey of Motorist Route Selection Criteria
7	78-11	Analysis of Driver Requirements for Intercity Trips
8	78-12	Analysis of Driver Requirements for Intracity Trips
9	78-13	A Study of Physical Design Requirements for Motorist Information Matrix Signs
10	78-14	Human Factors Evaluation of Traffic State Descriptor Variables
11	78-15	Human Factors Evaluation of Route Diversion and Guidance Variables
12	78-16	Supplement to Traffic State Descriptors and Route Diversion and Guidance Studies
13	78-17	Human Factors Evaluation of Audio and Mixed Modal Variables
14	78-18	Point Diversion for Special Events Field Studies
15	78-19	Freeway Incident Management Field Studies
16	78-20	Feasibility of Audio Signing Techniques
17	78-21	Driver Response to Diversionary Information

Part I of this Phase II report is an Executive Summary in which the background of the project and the results are summarized. In addition, lessons learned and recommendations for other motorist information and diversion projects are presented.

Part II of the report addresses the I-35 re-routing in San Antonio -- a measure designed to re-route non-local unfamiliar drivers. Part III discusses the implementation and effects of a changeable message sign system designed to divert drivers to an alternate freeway route when incidents occurred on the primary freeway. Studies discussing the effects of the changeable message signs during freeway maintenance operations are presented in Part IV. Part V discusses the changeable message sign hardware and operations, and highlights specific problems and recommendations. Data acquisition for point diversion projects are presented in Part VI.

The study was sponsored by FHWA and conducted by the Texas Transportation Institute in cooperation with the Texas State Department of Highways and Public Transportation (TSDHPT), the San Antonio Police Department (SAPD), the City of San Antonio, and the San Antonio Corridor Management Team.

The authors acknowledge the San Antonio Corridor Management Team, who conceived and implemented the Motorist Information and Diversion System. Special acknowledgment is expressed to Messrs. Milton Dietert, Gene Sparks, Herman Haenel, Gilbert Gavia, Bill Tucker, Harvey Beierle, Carl Wenzel, Frank Jacobs and Lawrence Allen of the TSDHPT, and Captain Patrick Nichols, Inspector Elroy Crenwelge, Sergeant Vick Abate and Detective George Davis of the SAPD for their assistance in this research effort.

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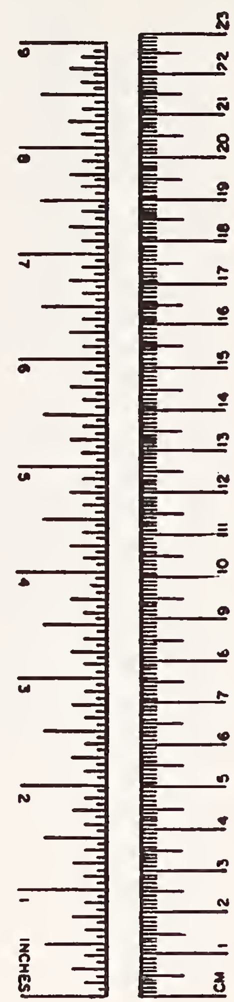
METRIC CONVERSION FACTORS

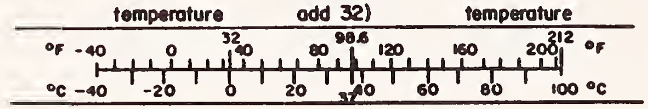
APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.6	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



APPROXIMATE CONVERSIONS FROM METRIC MEASURES

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	8.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	36	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PART I

EXECUTIVE SUMMARY

BACKGROUND

In 1977 the Texas State Department of Highways and Public Transportation (SDHPT), working in cooperation with the San Antonio Corridor Management Team (CMT), initiated programs aimed at alleviating congestion and reducing accidents on I-35 in San Antonio near the Central Business District (CBD). Among the programs were the development, implementation, and demonstration of a low-cost motorist information diversion system (MIDS) which included the following phases:

1. I-35 route change around the CBD,
2. use of a low cost changeable message sign (CMS) system for freeway diversion, and
3. use of the CMS system for managing traffic during freeway maintenance.

The Texas Transportation Institute (TTI) was contracted to evaluate the effectiveness of the above three programs as part of Phase II of the FHWA-sponsored research entitled, "Human Factors Requirements for Real-Time Motorist Information Displays." This provided an opportunity to not only evaluate the effectiveness of the specific traffic management approaches, but also to study the institutional and operational approaches used in San Antonio, and to develop hardware, operational and evaluation guidelines for other cities in the United States which may implement and evaluate similar type systems.

Freeway Facilities

The major freeway routes in the San Antonio metropolitan area are shown in Figure 1. Interstate 35 is the primary facility in the Austin-Laredo corridor and is one of the oldest freeways in San Antonio. The four-lane section of I-35 that forms the north and west boundaries of the CBD was completed in 1957. Considerable congestion and relatively high accident rates are experienced on this partially elevated freeway section that has capacity restraints such as relatively severe alignment and narrow right-of-way, particularly at the structures (1).

Interstates 10 and 37 are eight-lane freeways built in the late 1960s with higher design standards. As the southern and eastern boundaries, they form an alternate route around the downtown area. This route is approximately 0.8 miles (1.3 km) longer than the primary route [5.6 miles (9.0 km) vs. 4.8 miles (7.7 km)]. During off-peak periods travel time is lower on the alternate route. The AADT on I-35 in 1977 was approximately 79,230 in contrast to 58,140 on I-37.

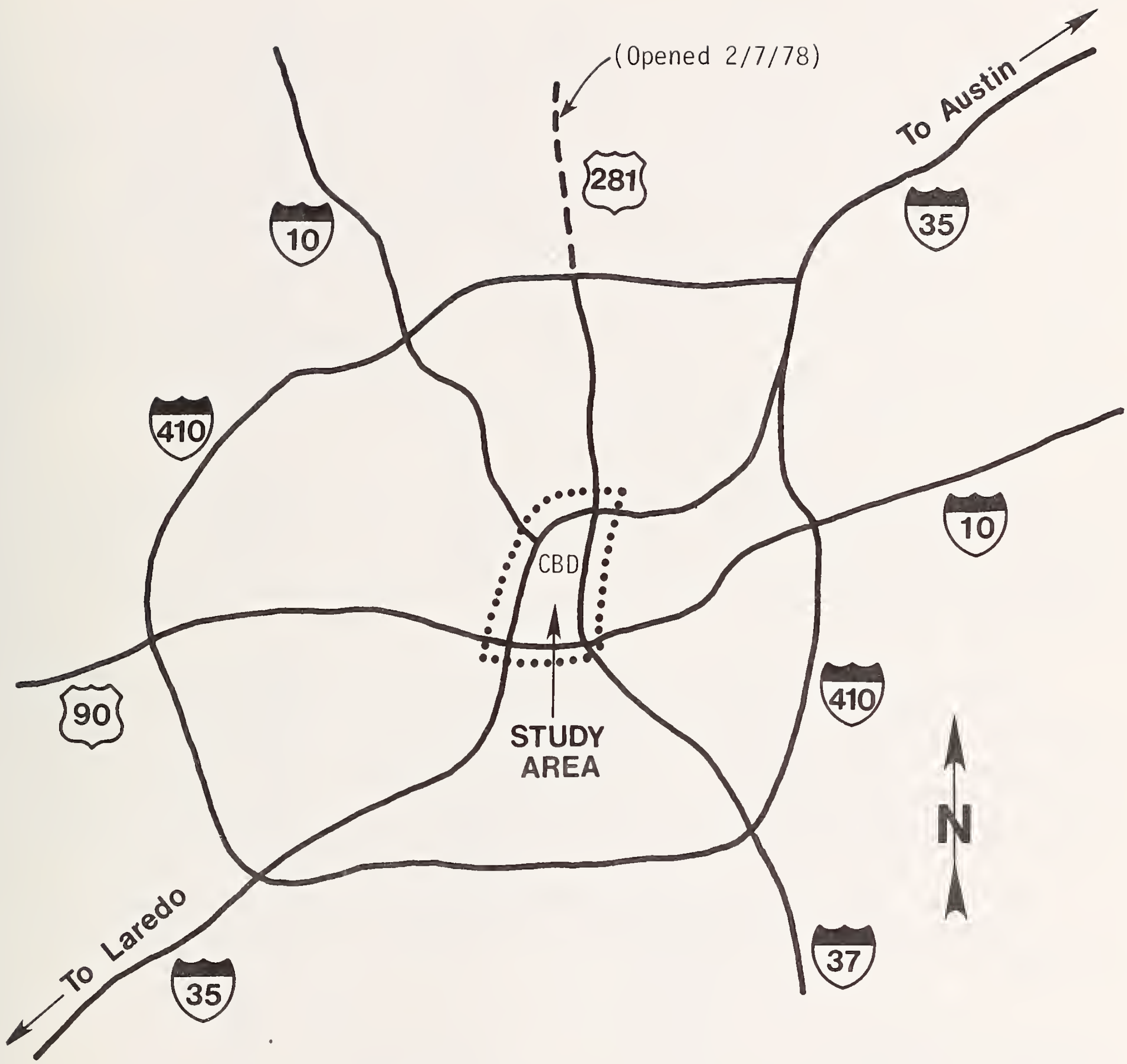


Figure 1 - Major Highways in the San Antonio Metropolitan Area

Traffic Management Approaches

As interim measures prior to the reconstruction of I-35, the San Antonio CMT decided to implement and test low cost traffic management strategies to alleviate traffic congestion and improve safety in the corridor. The first phase of the traffic management plan was to encourage thru drivers to use the better designed alternate freeway route. The approach taken was to change the routing of I-35 thru San Antonio from the west side of the CBD (primary route) to run concurrent with I-10/I-37 on the south and east sides (diversion route). This was accomplished by modifying the legends on the freeway guide signs upstream from all the major interchanges shown within the Study Area in Figure 1 and on the I-10/I-37 diversion route. In other words, signs that showed I-35 to follow the original route were changed to show it following the diversion route. The changes were designed to encourage unfamiliar non-local thru drivers to use the new route. Figure 2 illustrates the concurrent route markers before and after the sign changes. The sign modifications cost approximately $20,000 and were funded by the SDHPT.

The second phase of the management plan was aimed at the more familiar drivers. Two trailer mounted lamp matrix CMSs, available from previous TTI research studies, were installed on northbound I-35 upstream from the interchange to the diversion freeway route. The signs, shown in Figure 3, were operated by the San Antonio Police Department and were used to encourage drivers to use the diversion freeway route during incident conditions.

Figure 4 illustrates the CMS system operational approach used. Surveillance was accomplished by police freeway and helicopter patrols. Incident information and requests for sign messages were radioed to a police dispatcher who also controlled the CMSs. The dispatcher displayed one of several predetermined messages stored in the CMS computers using a teletypewriter input device interconnected with the signs by a telephone call-up system. Special telephone cards were used by the dispatcher to automatically dial the signs.

The third phase of the study involved the use of the CMSs to manage and divert traffic during freeway maintenance operations which necessitated lane closures.

Evaluation Approach

The effects of the redesignation of the I-35 route were measured primarily by license plate origin-destination (O-D) studies. These data were supplemented by a questionnaire survey administered separately by the SDHPT. The effectiveness of the CMS diversion system was studied by assessing the change in traffic volumes on the freeway, interchange ramps, and the primary off-ramps leading to the CBD. Effectiveness of the system as perceived by the police patrols was evaluated by studying the willingness of the police to use the CMSs during incidents over a period of two years.

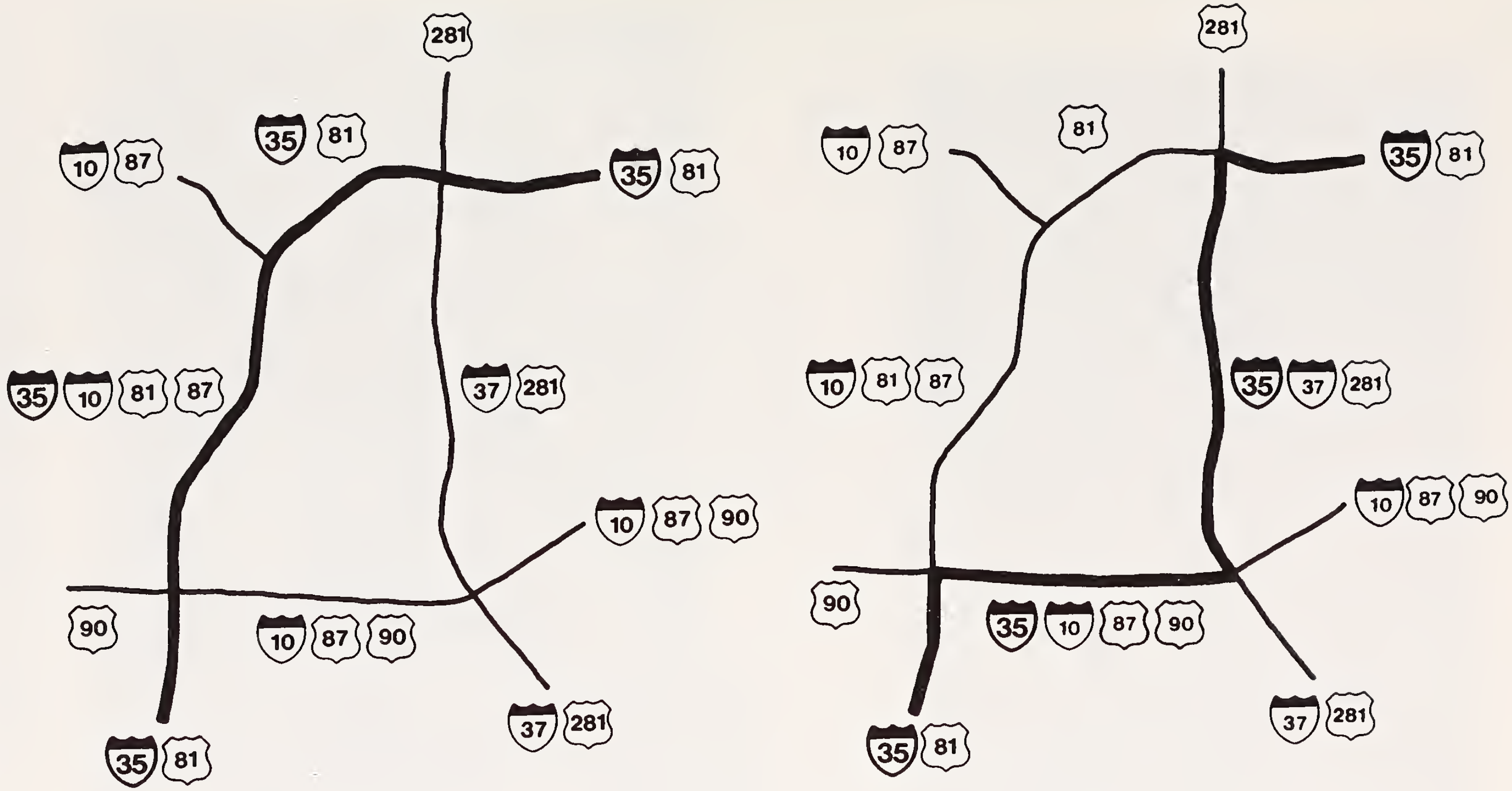


Figure 2 - Routes Before and After Sign Changes

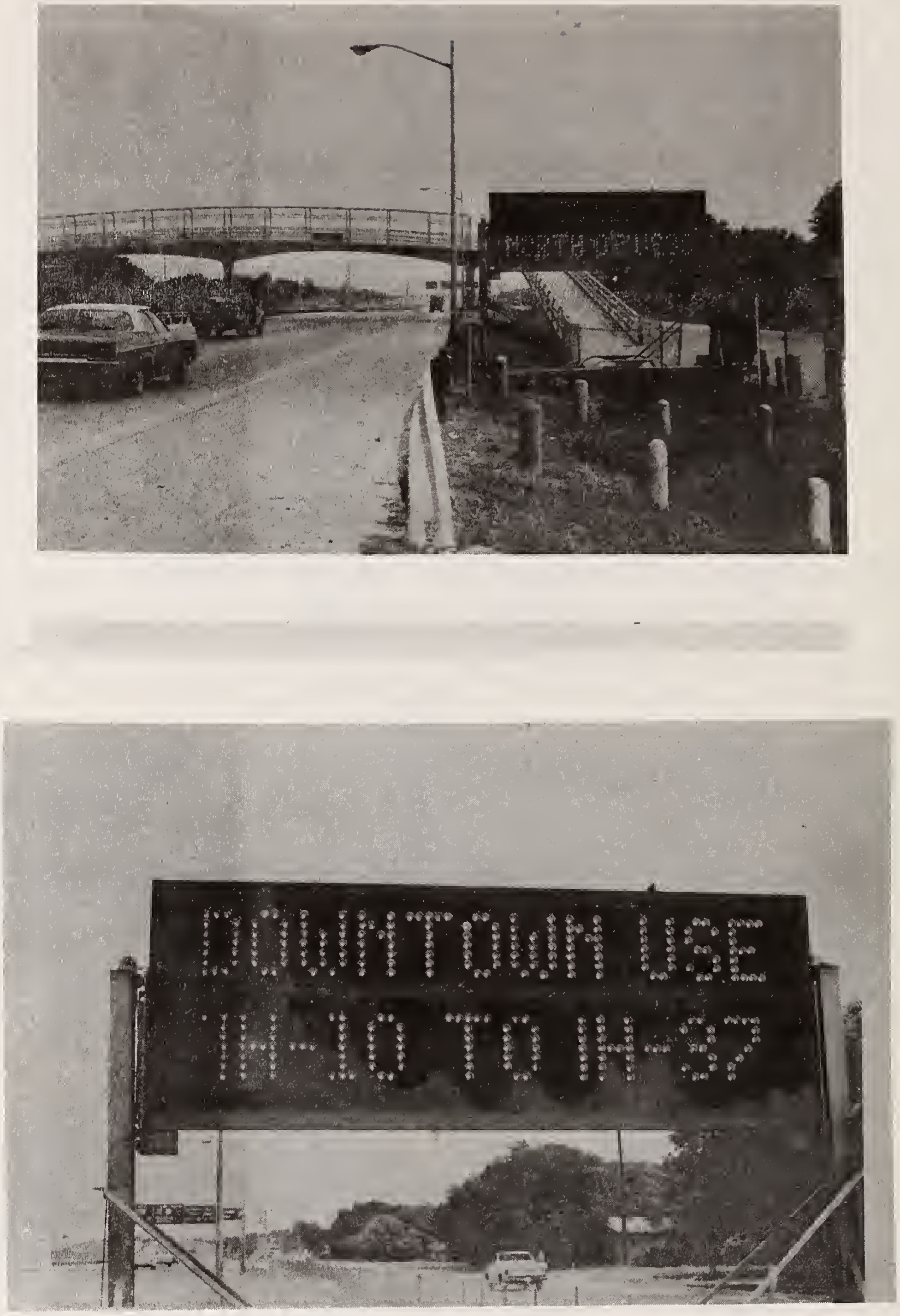


Figure 3 - Changeable Message Signs
Used in San Antonio

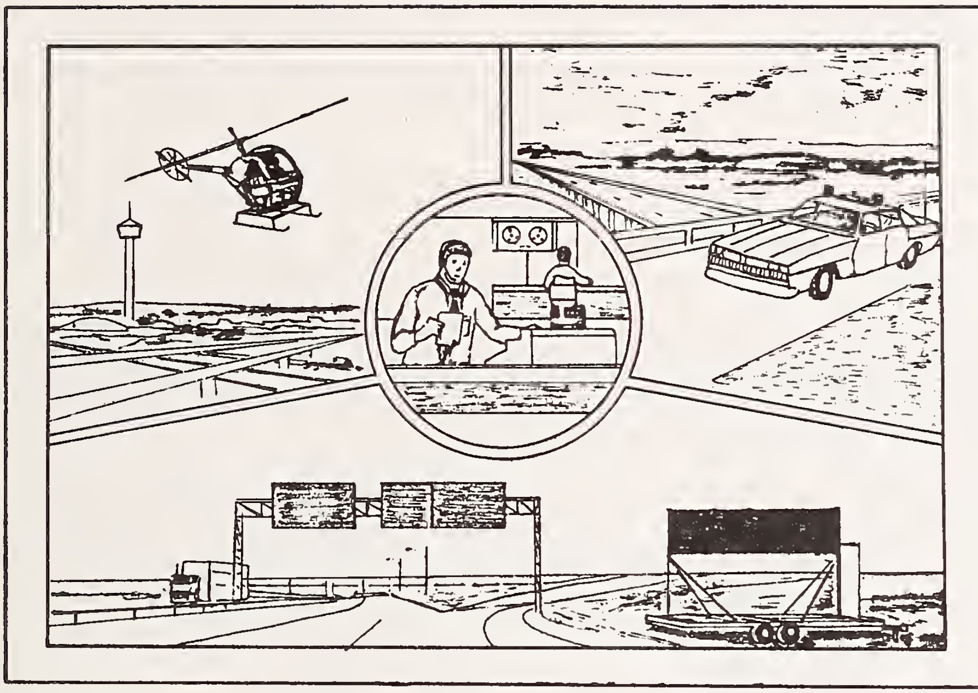


Figure 4 - Schematic of CMS Motorist Information and Diversion System in San Antonio

Lane distribution measurements and license plate O-D data were collected to evaluate the use of the CMSs during freeway maintenance.

SUMMARY OF RESULTS

Route Redesignation

Approximately 4500-4800 vpd or only about 10-11% of the northbound I-35 traffic was thru traffic (i.e., traveling on I-35 thru the CBD area).

Redesignation of the I-35 route resulted in a 6% shift in thru traffic from the primary to the diversion route. Prior to the sign changes 22% of the thru drivers used the diversion route. This increased to 28% after the sign changes. The 6% increase represented about 325 (northbound) vpd.

The sign changes, as expected, did not alter the route choice of local drivers but did influence non-local thru drivers. Prior to the sign changes only 10% of the non-local thru drivers traveled on the diversion route. After the sign changes 33% used the route.

The small shift of thru traffic (650 vpd) was attributed to the fact that 79% of the thru motorists were local drivers; whereas only 21% were non-local drivers. Since the sign changes were directed at the non-local drivers, it was estimated that the potential diversion was only 1500 vpd.

Freeway-to-Freeway Diversion

Analysis of seven incident case studies for which all relevant data were available revealed that, on the average, diversion rates when the CMSs were used were higher than normal, but were about the same as the natural diversion that occurred due to incident congestion when the CMSs were not used.

Two factors seemed to contribute to the less than acceptable results:

1. The diversion ramp was too close to the final destinations of divertable (CBD-bound) drivers. Thus, the amount of time saved by taking the diversion route was probably not sufficient to encourage diversion.

2. Drivers were using routes other than the diversion route when they saw messages on the CMSs. Diversion to these other routes were not evaluated as part of the point diversion project.

Therefore the results do not indicate failure of the MIDS, but the fact that the advice came too late under the circumstances. In addition, some drivers knew better (in their viewpoints) routes.

Freeway Maintenance

Results of the studies during nighttime freeway maintenance operations revealed that, when properly located, CMSs are effective in encouraging greater numbers of drivers to leave the closed lane farther in advance of the cone taper. In addition, CMSs can be used effectively in diverting traffic to an alternate freeway route to avoid the work area during nighttime freeway maintenance operations. Warning and diversion messages (i.e., messages which specify which freeway route to use) were displayed alternately. The diversion messages encouraged 15% more drivers to use the diversion route.

LESSONS LEARNED

The program in San Antonio was successful from several standpoints. First of all, it gave the San Antonio CMT, particularly the members of the Police Department, experience with operating a CMS system. It will be invaluable in the future when more elaborate systems are designed and implemented. Secondly, it illustrated how interagency teamwork can accomplish corridor management objectives. Thirdly, it allowed the research team to observe institutional, hardware and operational conditions and limitations. These observations, documented in this report, will assist other agencies contemplating the installation of similar systems.

Although the amount of traffic diversion attributed to the static sign changes and the CMSs may not be overly impressive, several lessons were learned from this low cost MIDS demonstration project which will be beneficial to others.

Re-Routing Non-Local Drivers Thru a Metropolitan Area

Re-routing an Interstate radial freeway through a metropolitan area can be achieved without creating major traffic operational problems. The primary target group for this change is non-local thru traffic. Experiences in San Antonio revealed that 23% more non-local drivers used the diversion route. However, the sign changes did not affect the route choice of local drivers.

In San Antonio, a radial freeway route (I-35) was changed. This was accomplished by switching the Interstate shield and control city name on the guide signs. The authors speculate that non-local thru drivers can also be encouraged to use a well-designed loop freeway around a metropolitan area by "pulling" the drivers thru by showing the control city route to follow the loop rather than the radial freeway. In other words, it may not be necessary to change the route of the radial freeway.

Experiences in San Antonio and subsequent studies elsewhere in Texas, strongly indicate that the amount of thru traffic may not be as large as most local highway agencies speculate. Studies revealed that only about 10% to 11%

of the traffic on the I-35 radial freeway was thru traffic, and this was on a 6-mile (9.7 km) length.

CMS System For Freeway Point Diversion in Urban Areas

Establishing Amount of Potential Diverters

As previously noted, the amount of thru traffic in a metropolitan area may be relatively small in comparison to the total volumes.

Before implementing a MIDS, agencies should conduct thorough O-D studies to determine the amount and destinations of traffic. The studies will aid the agency in determining the audience to address and the best locations for the CMS.

Site Selection

Site selection as used here refers not to the location of the CMS itself, but to that part of the freeway system to which the CMS is addressed. The Design Guide (2) adequately delineates the appropriate criteria for sign location. The primary considerations in site selection relate to that freeway section that is particularly susceptible to capacity-reducing incidents and to which there is an alternate route. Without these two conditions, the expenditures for a CMS installation may not be justified.

There are other considerations to be made in site selection. The human factors Design Guide (2) illustrates those considerations under which substantial diversion is probable; a minimum of 20 minutes delay (or inversely, time saved) appears to be a fairly reasonable value.

Recommendations--In selecting a site for implementation, careful consideration should be given to the amount of time that can be saved under conditions other than a total freeway blockage. When a freeway is totally blocked substantial natural diversion will likely occur in the absence of signing. However, when traffic is moving, however slow, many motorists are likely to stay on the original route unless convinced that considerable time can be saved by diverting.

It is suspected that such a phenomenon played a significant role in the effectiveness of this study installation. Though ideally configured with respect to alternate routes, the primary diversion point is less than 2 miles (3.2 km) from the majority of the downtown exits. Except under total blockage conditions, the motorist could not reasonably expect to save more than about ten minutes by traveling to the far side of the CBD to enter from the alternate route. Therefore, it is speculated that the majority of the potential diverters chose to wait in the queue and to take their normal route rather than journey into less familiar territory along the alternate route.

System Operation

The decision was made by the local highway and police agencies that the San Antonio CMS system would be operated by the San Antonio Police Department (SAPD). The SAPD administrators and supervisors were enthusiastic supporters and lent considerable encouragement for this arrangement. Many institutional, personnel and funding constraints limited the capability of the local police to staff the system to the levels needed to maintain an effective system during the two year study. However, the SAPD believes that the police should have operational responsibiity.

Recommendations--Some local police departments are in a position to assume responsibility for operating MIDSs in urban areas. When the system is to be operated by local or state highway agencies, the police should be involved with the planning and design of the system, and must be an involved partner when the system is operated.

Operator Considerations

Reports (2, 3) have cited factors such as operator boredom as critical in the effective operation of CMS systems. Although incidents are random and there may be long intervals when the signs are not needed, the preparedness and alertness of the operator must not significantly diminish. Operator overload, rather than boredom, was a problem in San Antonio.

The CMS system operator in San Antonio time-shared responsibility with dispatching police and other emergency vehicles to locations throughout the city. Needless to say, during the peak periods when the need for the CMSs was the greatest, the dispatcher was very busy responding to incidents. Overload in these critical situations required that the operator prioritized his tasks. Operation of the CMSs was of lower priority.

One major problem that arose in San Antonio was that because of the infrequent use of the signs by specific dispatchers due to shift rotations (signs are most frequently needed during peak periods) and other factors, the operators' self-confidence in the ability to operate the signs dwindled over time. This, in part, was a contributing factor to the decline in the use of the signs during the second year of operation. No provisions were made in the research project to retrain the operators.

Recommendations--The operator should be able to devote full attention to CMS operation during the peak traffic periods when incidents are most likely to occur. During off-peak periods other related tasks are advisable, but the operator must be in a position to devote full attention to the signs when an incident occurs.

The operator should have a strong working knowledge of the freeway and streets in the corridor influenced by the CMSs. This knowledge will permit him to more efficiently and effectively select the appropriate information options for display.

The operator must be well-trained and confident about his ability to operate the system. Recognizing that sign usage in the smaller metropolitan areas and in rural areas may be infrequent, provisions should be made to retrain the operators and to practice sign operation under simulated conditions. The CMS control console and associated hardware and software should be designed to allow the operators to go through the actual motions of operating the system and seeing the messages appear on the confirmation panel without the messages actually being displayed on the signs in the field. These simulations should be conducted with a supervisor at least every 6 months. The operator should be encouraged to practice the simulated operations on his own at more frequent intervals.

Operator's Control Console

The remote control console used in San Antonio was a teletypewriter (TTY). Although TTI researchers had no problems with the TTY while operating three trailer-mounted CMSs in Dallas (4), some of the police dispatchers seemed to be apprehensive about the equipment. The problem was compounded by the need to punch a "D" on the keyboard followed by a number. Some of the dispatchers lacked the confidence that the number they punched would display the desired message, even though they had a message number chart available.

There were also many occasions of dispatcher apprehension about whether the message requested was actually displayed. Although the message "D-number" was printed by the TTY printer when a message was displayed, the message content was not. This added to the operational uncertainties.

The amount of operator action to display a sign message after a sign was "contacted" was excessive. As many as seven buttons on the keyboard had to be depressed merely to display one message and to have the D-number and computer clock time printed.

Recommendations--A TTY remote control console can probably be effectively used in an urban area CMS system to control up to three CMSs by a technically oriented individual provided he can devote full attention to operating the signs needed to be activated. A push button console should be used when the system is operated by local or state police or non-technical personnel, or the system has more than three CMSs. The push buttons should contain the specific CMS message that will be displayed when the buttons are depressed.

Positive visual message verification should be provided. A message display board should be available when either the signs are operated by non-technical personnel or when there is a large number of signs to control. The message display board must allow the operator to quickly identify the exact message content and the freeway locations where messages are displayed. Simultaneous display of the information is desirable. Technically oriented operators probably could get by with a CRT display provided the number of signs is small.

Telecommunications

As previously discussed, the operator's console (TTY) in San Antonio communicated with each sign by way of a telephone dial-up system. This required that a sign had to be called before a message could be displayed, changed, or removed. Although the amount of time required would not be excessive and the efficiency of operation would not be seriously affected for a two-sign system with an experienced operator, problems could arise with larger urban area systems or when operators are not proficient in the use of the CMS system. Experiences with the telephone dial-up system in San Antonio indicated that it was quite inadequate for the occasional user who had a multitude of other simultaneous responsibilities.

Recommendations--It appears that the telephone dial-up system may be adequate for a small number of isolated CMSs in urban areas or for small CMS systems in rural areas. However, most urban systems should employ other telecommunications techniques to minimize the time required to change messages on the signs.

Surveillance

Surveillance is required for incident detection and an assessment of the operating conditions in the corridor. Detection of incidents, especially during peak periods, posed very little problem in this study. The thoroughness with which the SAPD covered the freeway system with ground and air units reduced incident detection time to the lowest time possible without extensive freeway instrumentation. For maximum effectiveness, incidents should be detected rapidly enough to allow the initiation of diversion before the exits to alternate route(s) are blocked by the queue from the incident.

Accurate identification of the incident location is also critical. Selection of messages is highly dependent on the location of the incident. The more specific the description of the incident in the CMS messages, the more critical the identification of the incident location becomes. For example, "ACCIDENT AT DURANGO" requires a much more accurate location determination than does "ACCIDENT NORTH OF US-90."

A second important function of surveillance is to provide information about conditions in the corridor. In San Antonio, the dispatcher/sign operator had to rely on those officers in the field to describe the conditions on the freeway. The patrol officers were in most cases so busy with investigating the incident and moving traffic, that they were not able to provide this information to the operator. Thus, the operator was required to "blindly" operate the CMS without having the assurance and confidence that the messages he displayed were the correct ones for the existing conditions. Eventually, some of the operators decided not to use the signs.

Recommendations--Use of police patrols is a good inexpensive way to identify the occurrence and location of freeway incidents in small metropolitan areas. It is not adequate to provide detailed information concerning the traffic

conditions on the freeway so that the operator can make appropriate decisions about the messages. Electronic detector surveillance complemented with closed circuit television are necessary parts of a CMS system in urban areas.

Evaluation Techniques and Hardware

Attempts were made by TTI to develop a simplified evaluation technique for the MIDS which could be easily implemented by city and state highway agencies. Previous studies in Dallas (5) indicated that diversion could be measured adequately at the diversion ramps. Thus, in San Antonio, six temporary automatic counters were installed at key freeway and ramp locations. Counts were taken in five minute intervals between the hours of 7am and 7pm. Information extracted from police accident reports and CMS teletype printouts were used to define the situations and time periods for which volume data were analyzed.

The volume count approach to measure point diversion would have been adequate in San Antonio if the amount of diversion was higher than that experienced. However, it is not sensitive to small diversion rates.

Only point diversion volumes were measured in this project. Experience in San Antonio indicated drivers were diverting to other routes that were not instrumented with volume counters. The evaluation plan used in this project did not provide for measurement of those traffic volumes that were input to and output from the freeway system at all locations in the study area. Neither did it provide for measurement of detection of accidents or queueing in terms of location and time.

Recommendations--This project focused on point diversion and did not measure the total effects of the CMS system. Agencies should recognize the probability of peak-period commuters selecting other routes than that intended by the agency. Thus, the evaluation procedure should include an assessment of these other routes. Detectors placed on exit ramps, other than the diversion ramp, which drivers may use after reading the CMSs should be included in the evaluation plan.

PART II

RE-ROUTING OF I-35

Chapter 1

INTRODUCTION

Objective

The purpose of the I-35 route change was to encourage thru drivers to use the diversion freeway route which had considerably higher available capacity than the primary route. The objective of the research studies were to determine the effectiveness of the route change.

Because of funding constraints the decision was made by FHWA to only study the northbound direction of flow. Effects on southbound I-35 and traffic from I-10, I-37, and US-90 were not directly evaluated.

Sign Changes

In November 1977 the SDHPT modified the freeway guide signs on the approaches to the major interchanges near the CBD (shown previously in Figure 1) to reflect the route change. In other words, signs that showed I-35 to follow the primary route were changed to show I-35 following the diversion route.

For emphasis and consistency in signing practice, both the Interstate shield and the destination city (Austin for northbound, Laredo for southbound) were changed. Interstate 35 shields and the Austin or Laredo destinations were added to all appropriate signs along the I-10/I-37 route. However, the I-35 shields were not removed from the signs located on the primary route beyond the interchange with the diversion route (i.e., the primary route immediately adjacent to the side of the CBD). Figures 5 and 6 illustrate the changes made to the guide signs on northbound I-35 approaching the south side of the diversion route. Sign changes on the other freeway links for northbound I-35 are shown in Appendix A.

Study Approach

Studies undertaken to evaluate the route change included the following:

1. estimation of the number of potential diverters,

2. estimation of the northbound and southbound thru drivers that diverted soon after the sign changes,

3. identification of the characteristics of diverting drivers, and

4. estimation of the effects of the sign changes in terms of total volume changes on the primary and diversion routes.

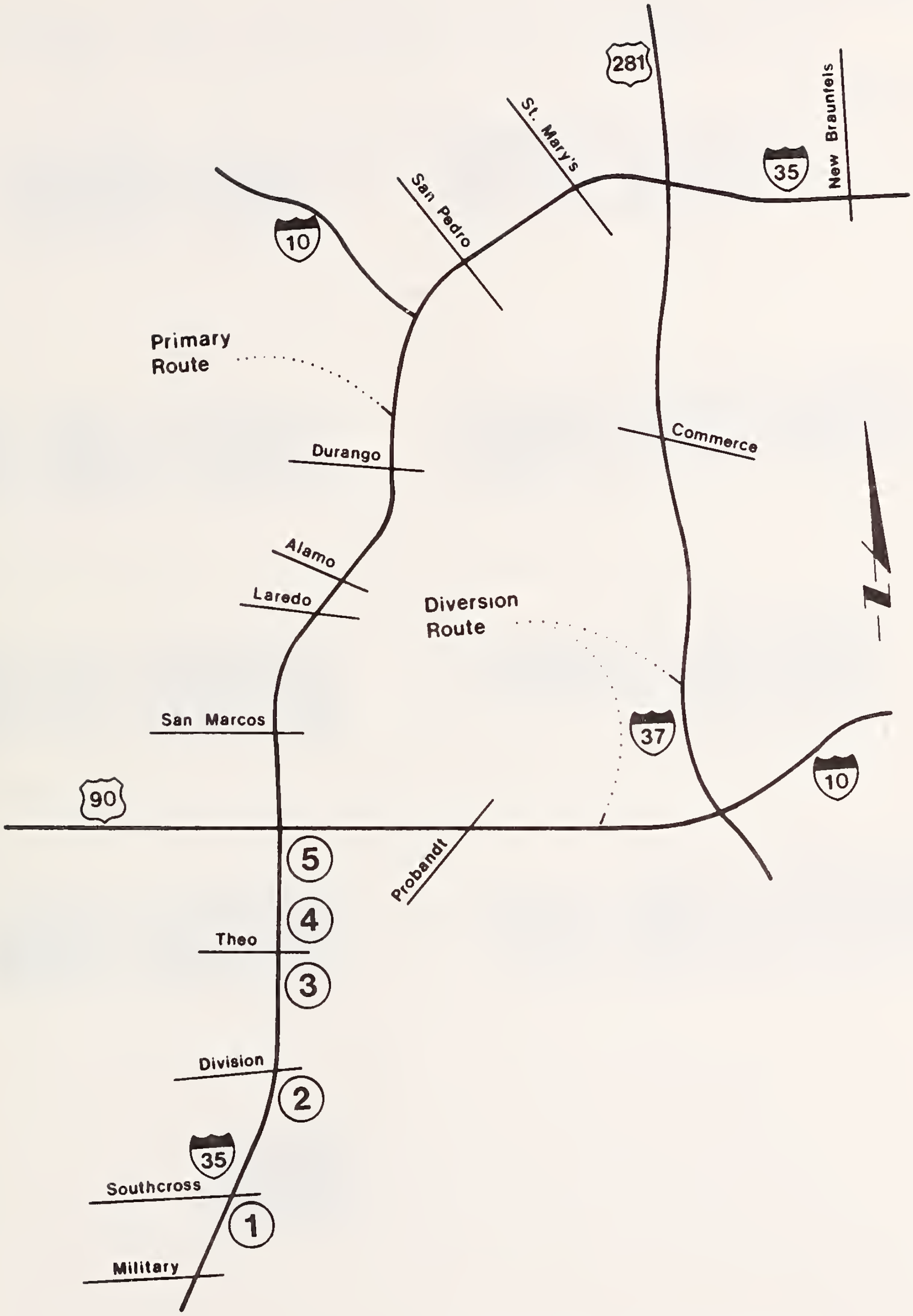


Figure 5 - Locations of Guide Signs on Northbound I-35 Approaching Diversion Route

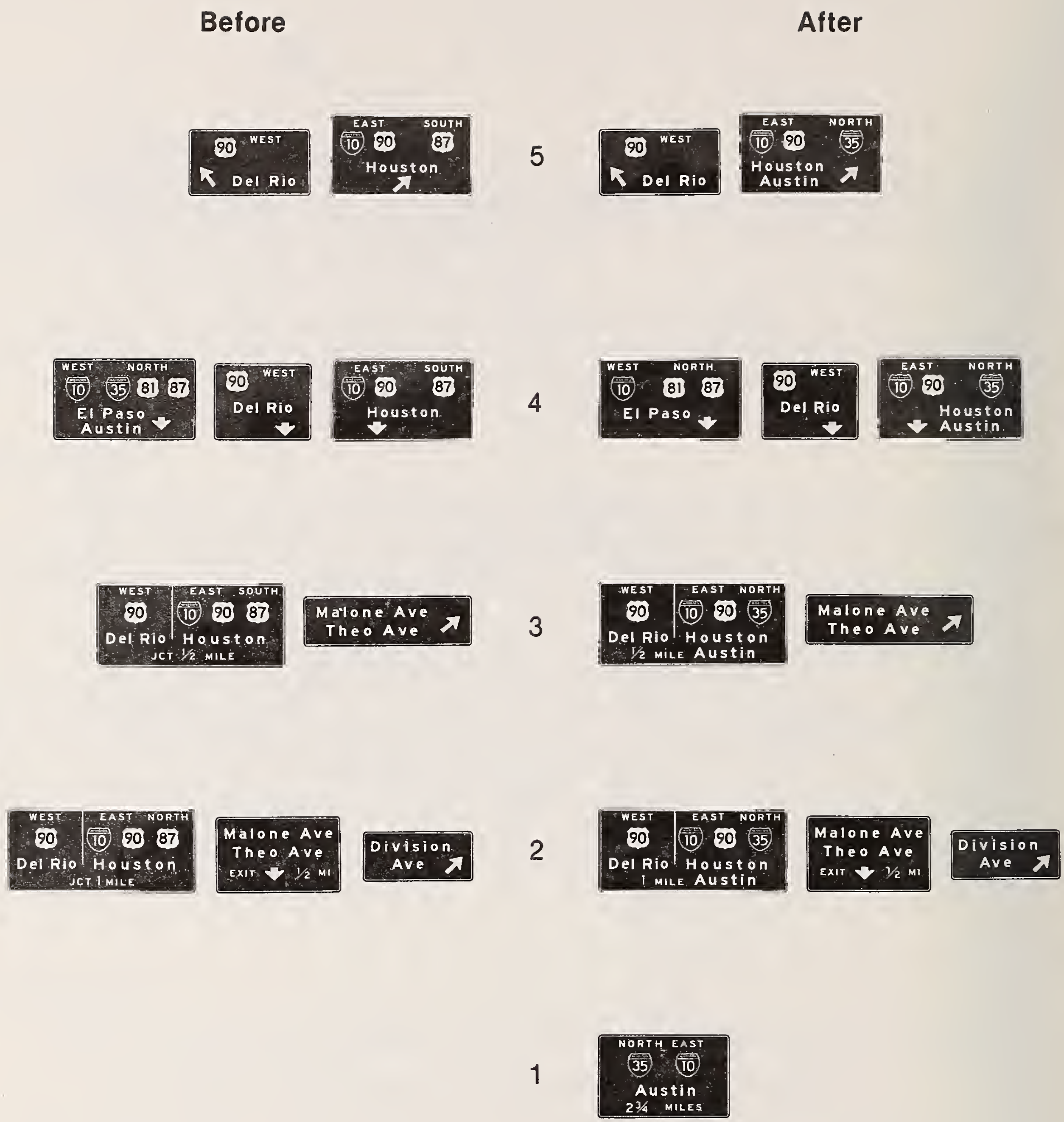


Figure 6—Guide sign modifications on northbound I-35
approaching diversion route

The studies included a combination of traffic volume, license plate O-D and video studies, and the interpolation of existing SDHPT planning survey data (e.g., questionnaire data) reported for the San Antonio area.

Details of the studies and subsequent results are discussed in Appendices B thru F. The general study approach and the more relevant results are summarized in the sections that follow.

Chapter 2

DIVERSION EVALUATION

Objectives

The primary objective of this phase of the study was to determine how many drivers on northbound I-35 shifted to the diversion route as a result of the static sign changes. Specifically, the objectives were to:

1. estimate the number of potential diverters, and
2. estimate the amount of diversion.

Approach

The critical task in this phase of the study was to estimate the existing thru volumes on the primary and diversion routes. A "thru" trip is one with an origin south of the diversion point (i.e., south of the I-35/I-10E interchange) and a destination north of the point where the diversion route joins back with the primary route (i.e., north of the I-35/I-37 interchange northwest of the CBD). Estimation of the existing thru volumes involved the following steps:

1. Determination of the number of thru drivers from previous SDHPT planning survey O-D data;
2. Development of traffic growth factors in the corridor; and
3. Extrapolation of the O-D data to the study year (1977).

The distributions of thru drivers by route (primary and diversion) both before and after the sign changes were obtained from license plate studies.

An estimate of the daily thru traffic on each route was obtained using the following equation:

$$\begin{matrix}\text{Thru}\\ \text{Traffic}\end{matrix} = \begin{pmatrix}\text{Total}\\ \text{Traffic}\end{pmatrix} \times \begin{pmatrix}\text{Thru}\\ \text{Fraction}\end{pmatrix} \times \begin{pmatrix}\text{Seasonal}\\ \text{Correction.}\end{pmatrix}$$

Total traffic is the 24-hour count of all northbound vehicles taken just upstream from the diversion point. These data were determined from automatic traffic recorders installed for this study.

Thru fraction is the proportion of the total thru traffic measured on each route. This proportion was obtained by recording license plates of all northbound vehicles upstream from the diversion point and at the ends of the primary and diversion routes. These plate numbers were then matched to determine the total number of thru drivers on each route, and subsequently, the ratio of thru drivers to total traffic and the amount of potential diverters.

Seasonal correction factors were used to convert the measured volumes into annual rates. These factors were computed from volumes obtained by the SDHPT from permanent traffic counters.

License plate data collected for four hours during the off-peak on a Friday and four hours on a Saturday both before and after the sign changes were matched using existing computer routines. Volumes were adjusted to reflect the number of license plates that were not read by the observers and the number of misread license plates. (See Appendix K for discussion of a license plate O-D accuracy study.)

Results

A comparison of the total thru traffic on northbound I-35 is summarized in Table 1. The results show that 10.2% of the total traffic was thru traffic during the before study period. After the sign changes, 11.2% was thru traffic. Statistical evaluations revealed that the percentages were not significantly different ($p<.05$).

The low percentages of thru traffic (10.2% and 11.2%) were somewhat surprising, particularly since the freeway length under study was less than 6 miles (9.7 km). Estimates furnished by the SDHPT from planning data indicated that the percentage of thru traffic would be higher.

Subsequent license plate O-D studies conducted by the SDHPT in other Texas urban areas reconfirmed the fact that the amount of thru traffic on a section of urban freeway of about 6 miles (9.7 km) is much lower than most highway agencies have realized. Traffic interchanging (exiting and entering) within the section constitute the large majority (perhaps over 80%) of the volumes on the freeway. These findings should alert other agencies to the need to conduct a thorough O-D study within a freeway corridor to establish the extent of the divertable traffic.

Table 2 summarizes the route choice by thru drivers. The data show that prior to the sign changes, 22% of the thru drivers used the diversion route; after the sign changes, 28% used the diversion route--a 6% increase. Further analysis revealed the 6% increase to be statistically significant ($p<.05$).

Daily and seasonal correction factors were developed from historical traffic volume data furnished by the SDHPT and applied to the license plate O-D data to estimate the amount of diverting traffic influenced by the sign changes. The results, shown in Table B-8 in Appendix B, revealed that an estimated average of 1,000 northbound thru vpd used the diversion route prior to the sign changes. In comparison, 1,325 thru vpd traveled on the diversion route after the sign changes--an increase of 325 vpd which was found to be statistically significant. If one can assume that the effects of the sign changes were similar for southbound traffic, it is estimated that approximately 650 thru drivers on northbound and southbound I-35 were diverted each day as a result of the static sign changes.

TABLE 1

COMPARISON BETWEEN THRU DRIVERS AND TOTAL NORTHBOUND VOLUMES

	Total Northbound I-35 Traffic at Theo	Thru Traffic		Thru Drivers on Primary Route		Thru Drivers on Diversion Route	
		Number	Percent	Number	Percent	Number	Percent
Before	20880	2130	10.3	1663	8.0	467	2.2
After	19884	2219	11.2	1605	8.1	614	3.1

TABLE 2

ROUTE CHOICE OF THRU DRIVERS

	Total Northbound Thru Drivers	Thru Drivers on Primary Route		Thru Drivers on Diversion Route	
		Number	Percent	Number	Percent
Before	2130	1663	78	467	22
After	2219	1605	72	614	28

*Data were collected between 10-11 a.m., 1-2 p.m., 3-4 p.m., and 5-6 p.m. Before data on Friday, September 23, 1977 and Saturday, September 24, 1977; after data on Friday, January 13, 1978 and Saturday, January 14, 1978.

Chapter 3

OPERATIONAL EVALUATION

Objectives

The objective of this study was to determine whether the sign changes resulted in any operational problems at the major interchanges where diverting drivers had to make changes.

Approach

Several hours of video recordings were made at the first two critical interchanges (i.e., I-35/I-10E and I-10E/I-37) on the diversion route. The video was later studied to identify any problems such as erratic maneuvers.

Results

Analysis of video tapes and on-site observations identified some minor operational problems immediately following the sign changes. At the primary diversion point (I-35/I-10E) operation was satisfactory, although a few drivers were observed exiting to I-10 from other than the outside freeway lane. It could not be established whether these erratic maneuvers were due to last minute decisions or to confusion due to the sign changes. The actual number of such maneuvers, however, was relatively small. It is concluded that the signing changes had no appreciable effect on erratic maneuvers at the interchange.

The one-lane [28-ft. (8.5 m) paved surface] connector ramp from I-10 eastbound to I-37 northbound was restriped by the SDHPT to form a two-lane connection to increase the capacity of that link of the diversion route. A minor operational problem was noted initially on the eastbound approach where drivers appeared to be accustomed to the one-lane exit that had existed prior to the sign changes. This complication resulted from incomplete removal of the old pavement markings. Once the pavement markings were completely removed, drivers began using the two-lane exit fully and no additional problems were exhibited.

Chapter 4

CHARACTERISTICS OF THRU DRIVERS

Objectives

The objectives of this portion of the study were to determine the characteristics of thru drivers in terms of:

1. typical origins and destinations, and
2. familiarity with alternate freeway routes around the downtown area.

Approach

Questionnaires were mailed before and after the sign changes by the SDHPT to northbound thru drivers identified from the license plate studies. The questionnaires were coded by study time periods and driver travel route. The "after" questionnaire was also designed to query drivers as to whether they had any problems following the freeway guide signs through the study area. Copies of the questionnaires and an example of a cover letter are shown in Appendix C. Detailed results are discussed in Appendix D. The more relevant results are summarized in the following paragraphs.

Results

Frequency of Route Usage

Driver familiarity with the two routes in San Antonio were obtained indirectly because of the difficulty in obtaining the data directly. In this study "familiarity" was related to the frequency of route use. Drivers were asked to indicate the frequency with which they used each of the two routes. They were categorized by very familiar (1-5 times per week), familiar (1-3 times per month), somewhat familiar (less than once a month), and unfamiliar (never before). Drivers who had never taken the route were considered unfamiliar with the route. (It is recognized that there are some drivers who have never taken a route but may be somewhat familiar with its existence.) A comparison of route choice by familiarity with both routes is shown in Table 3. The data revealed that after the sign changes there was a 5% reduction (62% vs. 57%) in the proportion of thru drivers who were familiar or very familiar with both routes, coupled with a corresponding 5% increase (9% vs. 14%) in the proportion of drivers unfamiliar or only somewhat familiar. The freeway sign changes were directed at thru drivers less familiar with the routes. The data indicate that the increased use of the diversion route after the sign changes was a result of successfully attracting unfamiliar drivers to the diversion route.

TABLE 3

ASSUMED DRIVER FAMILIARITY BASED ON
FREQUENCY OF ROUTE USAGE

Before Sign Changes (N=394)

Diversion Route \ Primary Route	Very Familiar - Familiar	Somewhat Familiar Unfamiliar
Very Familiar - Familiar	62%	8%
Somewhat Familiar - Unfamiliar	21%	9%

After Sign Changes (N=405)

Diversion Route \ Primary Route	Very Familiar - Familiar	Somewhat Familiar - Unfamiliar
Very Familiar - Familiar	57%	8%
Somewhat Familiar - Unfamiliar	21%	14%

The percentage of non-local drivers using the diversion route tripled after the sign changes. As shown in Table 4, prior to the sign changes only 10% of the non-local drivers used the diversion route; following the re-routing, 33% used that route.

Determination of local or non-local status was made by obtaining the registered address of the vehicle owner based on the license plate number. Residences inside of Bexar County were categorized as local, those outside the County were considered as non-local. This approach probably categorizes many persons from adjacent counties as non-local who may be as familiar with the freeway system as drivers residing in San Antonio. Therefore, the shift to the diversion route by truly unfamiliar drivers was probably considerably higher than that previously discussed.

The relative consistency of the travel patterns of local drivers (Table 4) reinforces the premise that the target group in the re-routing was the unfamiliar/non-local driver.

Problems in Route Following

The primary difficulties in route following reported by the questionnaire respondents related to insufficient time to execute the desired maneuver. Strangely enough, the bulk of these complaints came from drivers recorded on the primary route after the sign changes. Their complaints were not highly specific, therefore, it was not always possible to tell whether they wanted to use the primary route and were upset because they were almost trapped into using the diversion route, or whether they wanted to take the diversion route and could not get to it. There appears to be no significant information or guidance to be obtained from these responses. A summary of the comments is shown in Appendix E.

TABLE 4

ROUTE CHOICE BY DRIVER RESIDENCE

Non-Local Drivers

Route	Before Sign Change	After Sign Change
Primary Route	90%	67%
Diversion Route	10%	33%
	100% (N = 298)	100% (N = 317)

Local Drivers

Route	Before Sign Change	After Sign Change
Primary Route	75%	76%
Diversion Route	25%	24%
	100% (N = 1103)	100% (N = 1166)

Chapter 5

CHANGES IN TRAFFIC VOLUMES

Objectives

The purpose of these studies was to estimate the effects of the sign changes in terms of total volume changes on the primary and diversion routes. Whereas the studies previously discussed focused on northbound I-35 unfamiliar drivers traveling thru the city, this study was designed to assess additional impacts such as the increased use of the diversion route by US 90 and I-10 traffic and by local drivers who now recognized the attractiveness of the new route.

Approach

The overall impact was assessed by analyzing volume data from four automatic traffic counters located within the study area (two on each route). Details are presented in Appendix F.

Results

The route redesignation resulted in a significant reduction in traffic volume on the primary route and a significant increase on the diversion route. This determination was made by comparing traffic volumes during the year of the sign changes to the previous year. The analysis included a period 12 weeks prior to the sign changes and extended to 12 weeks after the changes. In this manner, the effects of natural growth in traffic were separated from the changes due to signing.

The analysis period was somewhat foreshortened by the opening of the McAllister Freeway (US-281) on February 7, 1978. This facility, an extension of I-37 toward the northern part of the city, generated more than 40,000 vpd during its first week. Although this opening may have affected the primary route to some extent, its effect on the diversion route was substantial. It was therefore deemed appropriate to terminate the freeway volume analysis prior to the opening of the McAllister Freeway rather than attempting to separate the various effects.

Figures 7 and 8 graphically present the northbound volume trends on the two routes from September through March during the years 1976-77 and 1977-78. The data were obtained from SDHPT records of volumes collected at the north ends of both routes. The 1977-78 period in Figures 6 and 7 include volumes before and after the sign changes and a period following the opening of the McAllister Freeway (US-281).

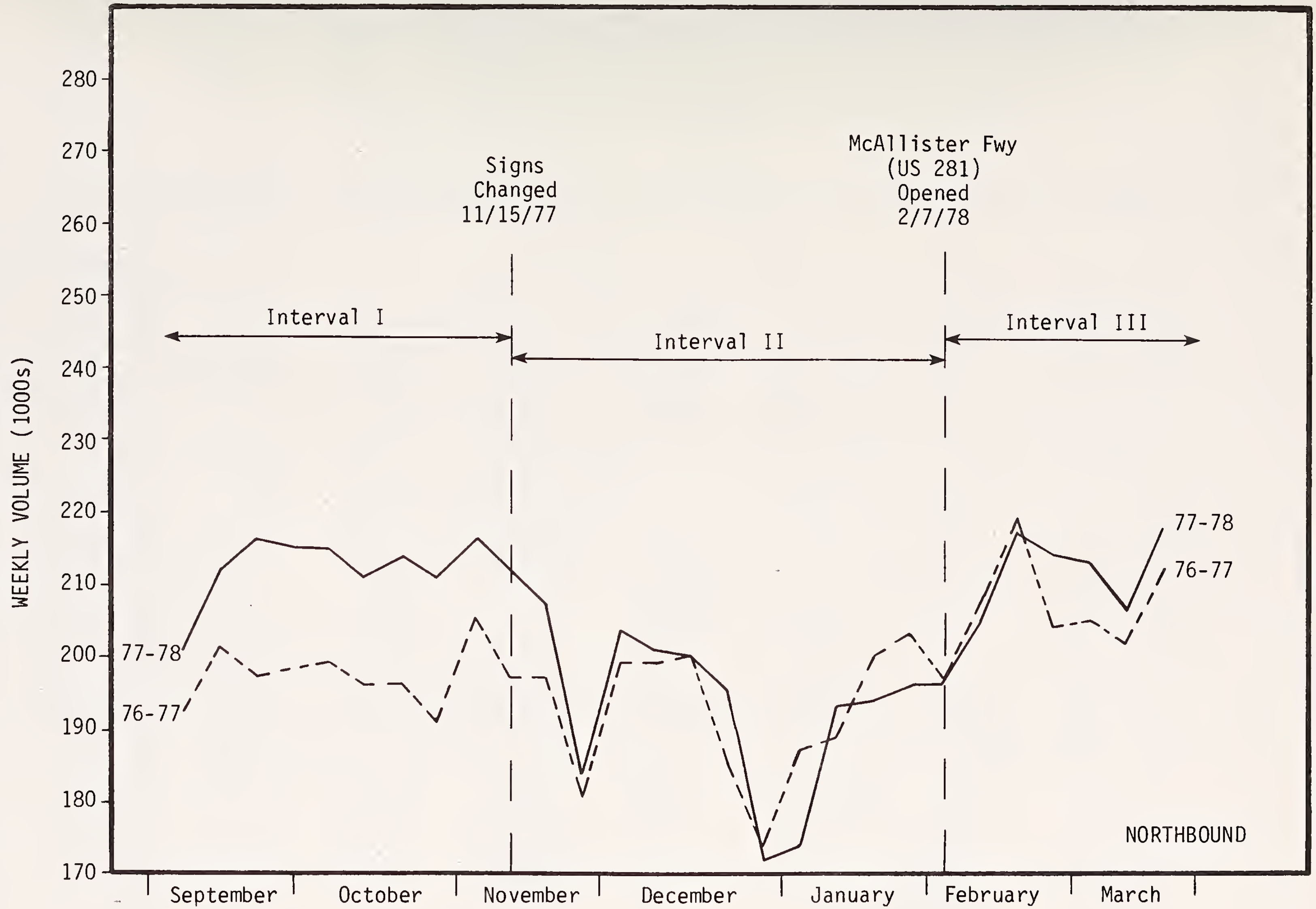


Figure 7 - Weekly Traffic Volumes on I-35 NB at St. Mary's

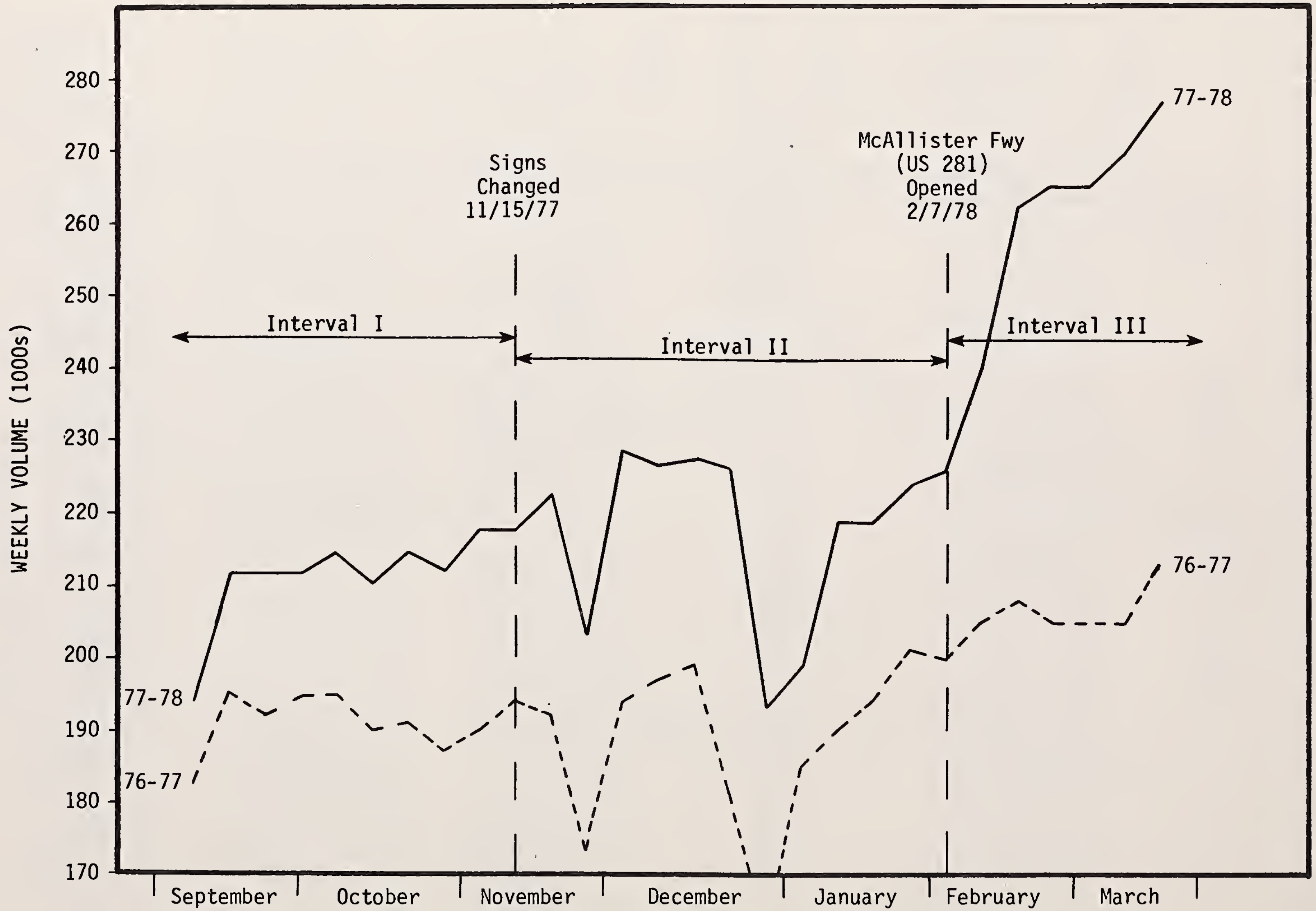


Figure 8 - Weekly Traffic Volumes on I-37 NB South of I-35 Exit

The following general observations may be made about the data shown on the Figures:

Interval I - September 1, 1977 - November 14, 1977
Prior to the changing of the signs, both northbound I-35 and I-37 showed substantial growth in 1977-78 over the same time period in 1976-77. As this growth was fairly consistent at both locations, there is little reason to expect the growth rate to decline.

Interval II - November 15, 1977 - February 7, 1978
After the static signs were changed to encourage the use of the diversion route by thru traffic, there was a marked decrease in traffic on I-35 (Figure 7). The reduction was to a level comparable to 1976-77. However, the volumes increased, though slightly, on I-37 (Figure 8). These increases appear to be greater than that experienced in Interval I. Thus, the volume trends indicate that the sign changes reduced volumes on I-35 and increased volumes on I-37.

Interval III - February 8, 1978 - March 31, 1978
Although these volume changes offer little in terms of evaluating the effect of the static signs, they demonstrate the necessity to terminate the analysis at the end of Interval II.

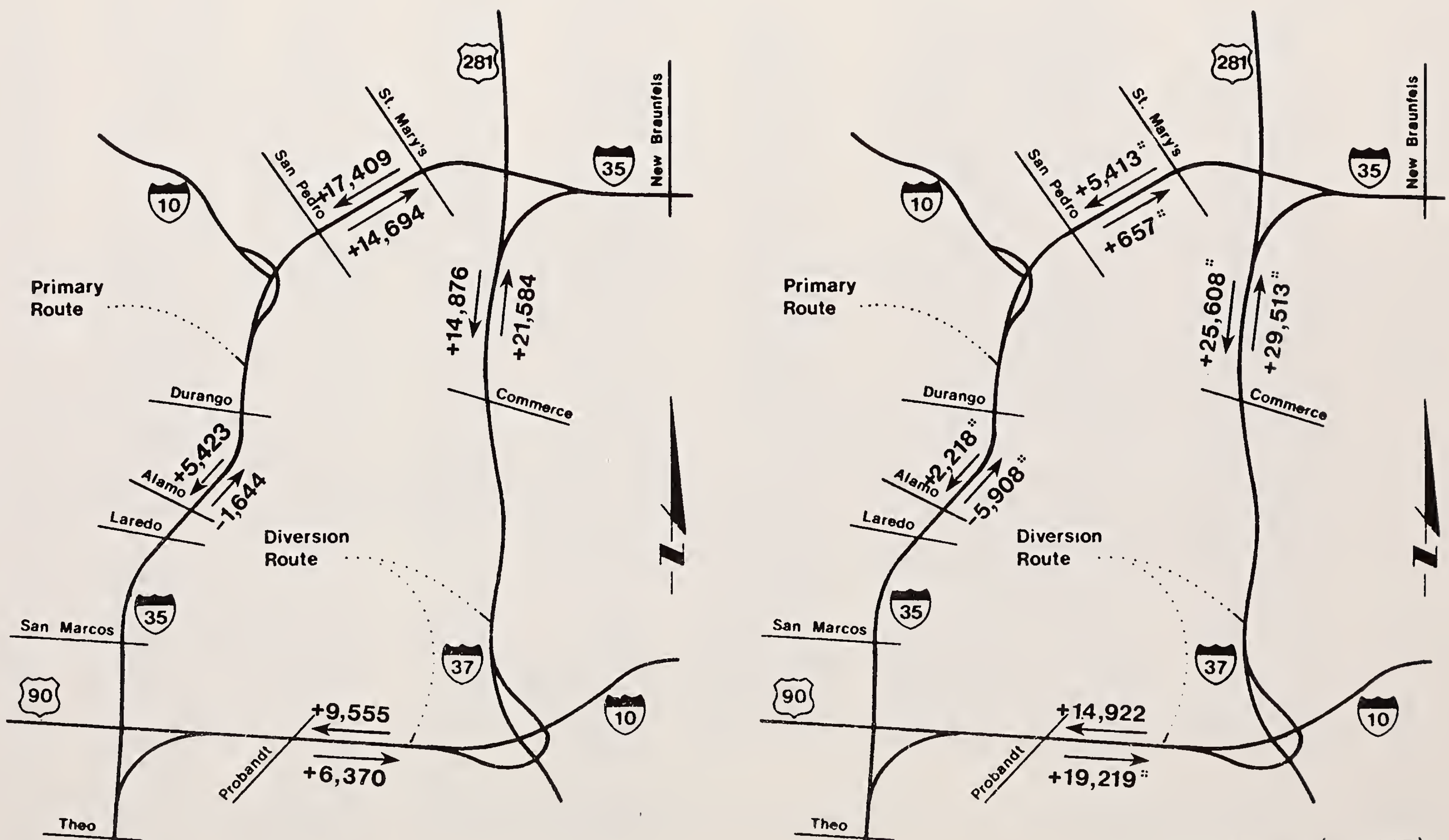
The data from the four permanent counters were further analyzed to establish whether the volume changes were due to the sign changes or whether they were due to normal growth (year-to-year comparison) and seasonal fluctuations (before-to-after comparisons for both years). Difference in weekly volumes for the two years was chosen as the measure for examination.

Figure 9 shows the difference in average weekly volumes at all four permanent count stations for the 12 weeks prior to the sign changes. As seen in the Figure, all stations except one showed average weekly increases in both directions.

Figure 9 also shows the difference in average weekly volumes for the 12 weeks after the sign changes. The counters on the primary route reflected smaller differences (or decreases) in volume in both directions after the sign changes. The diversion route counters showed increased differences.

Statistical analyses indicated that the effective reduction in expected volumes on the original route was significant ($p<.005$) in both directions at both locations. With the exception of westbound volumes on I-10, all increases in volumes on the diversion route were significantly higher ($p<.005$) than that experienced prior to the sign changes.

Although the analyses did not permit an estimation of the quantity of diverted traffic, the increase in average weekly volume on the diversion route



Before Sign Changes

After Sign Changes

⁘ Significant (p<.005)

Figure 9 - Differences in Average Weekly Volumes Between 1976-77 and 1977-78

and the decreases on the primary route may give some indication of the magnitude of the diversion.

The net two-way annual growth on the primary route was at least 1000 vpd less than expected after the sign changes. Similarly, the net growth on the diversion route was at least 2600 vpd more than expected. Therefore, it can be generally assumed that the shift from one route to the other was considerably greater than that estimated in previous sections. However, the impetus for the shift in volumes between the routes cannot be unequivocally ascribed to the signing changes.

PART III

CHANGEABLE MESSAGE SIGN SYSTEM FOR FREEWAY POINT DIVERSION

CHAPTER 6

OPERATIONAL DEVELOPMENT

Development of the CMS operations plan evolved over a period of several months and included the following activities:

1. identification of incident characteristics,
2. selection of sites for matrix signs,
3. determination of existing traffic patterns,
4. development of diversion strategies,
5. development of candidate messages,
6. development of operational control procedures, and
7. training of operating personnel.

Several meetings were held between the SDHPT, SAPD and TTI in an attempt to develop a plan that was both acceptable to the operating and enforcement agencies and incorporated available inputs of recent CMS operational guidelines.

Incident Characteristics

To ensure that the actions being taken were directed at the appropriate problems, the accident histories of the freeway sections involved were reviewed. It was found that of the 15 individual freeway segments surrounding the CBD, the top 8 in terms of accident rates were on the older, narrower section of I-35. In 1975, these segments had accident rates of 3.9 to 9.9 accidents per million vehicle-miles (6.3 to 15.9 accidents per million vehicle kilometers)(6). This finding reaffirmed the judgment of the CMT in singling out the old section of I-35 for alternative treatments.

Matrix Sign Sites

The locations of the CMSs were very important. The human factors Design Guide (2) emphasized the need to install CMSs far enough upstream from decision points to allow the driver time to take appropriate action. Yet, care had to be taken not to locate the signs so far from the diversion point such that a large majority of the traffic would enter the freeway on-ramps downstream from the signs and would not be able to read the message. It was also important for the signs to be close enough together for the information on the two to be reasonably connected. Finally, the CMSs had to be integrated into the overall freeway signing system to ensure that pertinent information on both the static and dynamic signs was compatible.

Site selection was constrained somewhat by the need to provide adequate sight distance to the signs and the need for sufficient right-of-way between the freeway shoulder and frontage road. Horizontal and vertical curvature and

right-of-way widths placed some restrictions on the site selection. Another influencing factor was the need to place the signs downstream from the Military Drive on-ramp which carries relatively high volumes in comparison with the freeway.

The sites chosen for the two CMSs are shown in Figure 10. The first sign seen by the driver was approximately 2.2 miles (3.5 km) from the diversion point, Sign 2 was approximately 1.0 mile (1.6 km) downstream from Sign 1.

Existing Traffic Patterns

Knowledge of existing traffic patterns of northbound I-35 motorists was important for two reasons. First, it was essential to know the destinations of the drivers in order to determine the potential "audience" for diversion. Secondly, it was important to establish base data for comparison with data collected during CMS operations to determine whether significant diversion had been achieved.

The initial base condition study was a limited license plate O-D survey conducted in January 1978. This study involved the recording of license plate numbers of all northbound vehicles at the locations shown in Figure 11 to establish basic travel patterns and the potential diversion audience.

Assumptions were made in order to limit the study size and conserve on funds. Although there are several entries into the downtown area from the west side of the CBD, it was assumed that the vast majority of CBD-bound drivers would normally take the exit marked "DOWNTOWN" (Durango Exit). It was also assumed that the westbound I-10 traffic would not have significant bearing on the analysis. These assumptions later proved to be partially incorrect.

The decision on the appropriate diversion audience to be addressed by the CMSs was fairly clear after the first set of license plate O-D studies. Matched license plates showed a distribution of destinations for the potential diversion audience similar to that shown in Figure 12. Significant destinations included downtown (50% of the matches) and thru (42%). Fort Sam Houston, though a major local generator, seemed to attract little traffic from the Laredo corridor.

Assumptions regarding the accuracy of the estimates of thru traffic and downtown traffic entering from the east side of the CBD on Commerce Street were valid. All practical options had been covered. However, the assumption that Durango Street was the only practical west side entrance was less sound because there were other off-ramps between the I-35/I-10E interchange and Durango. The assumption became even more suspect when a preliminary analysis showed only small volume changes on the Durango ramp when the CMS displayed a message.

A follow-up O-D study was conducted in March 1979 that included all west side CBD entry points and both major interchanges on the west side of the CBD.

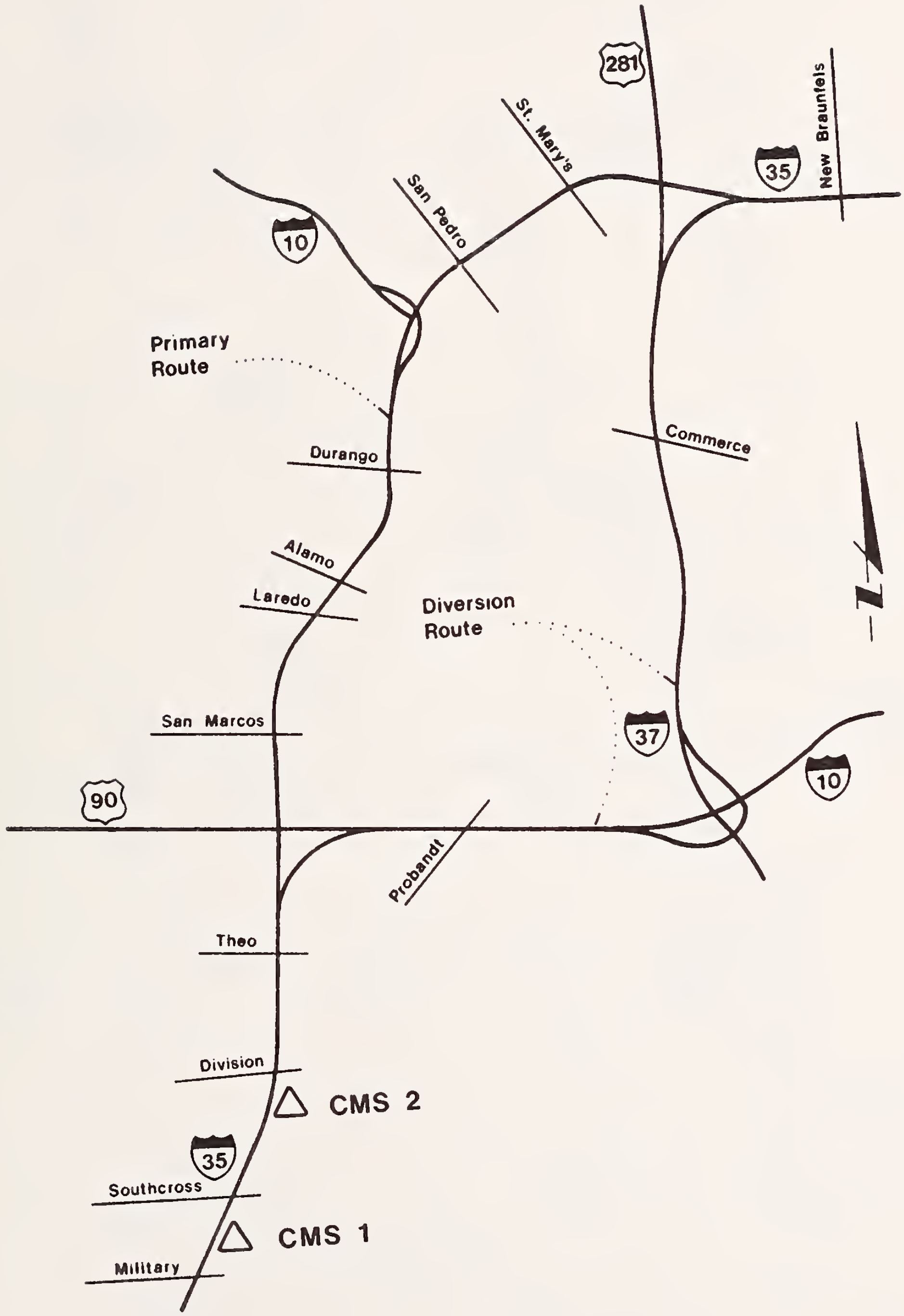


Figure 10 - Location of Changeable Message Signs

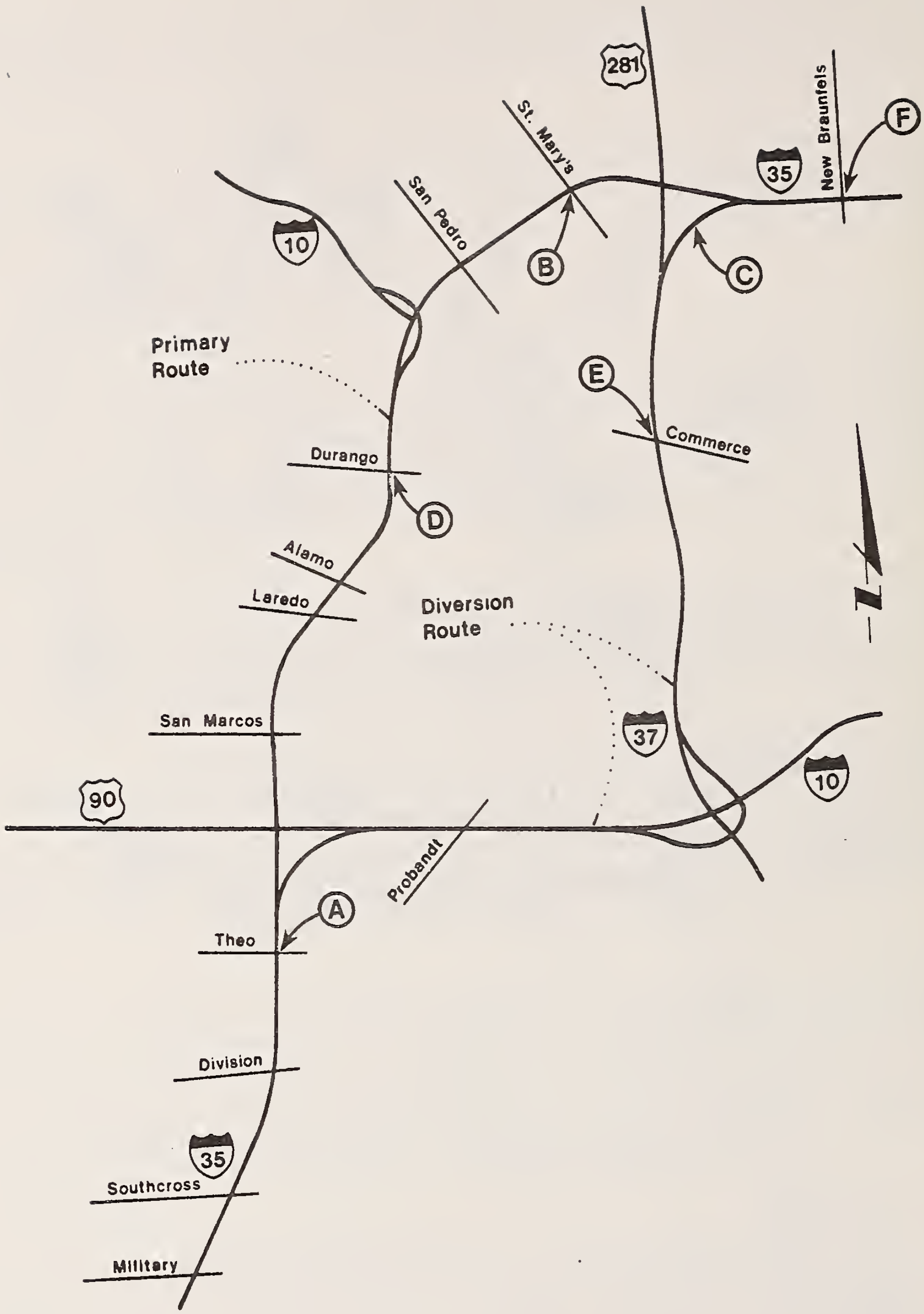
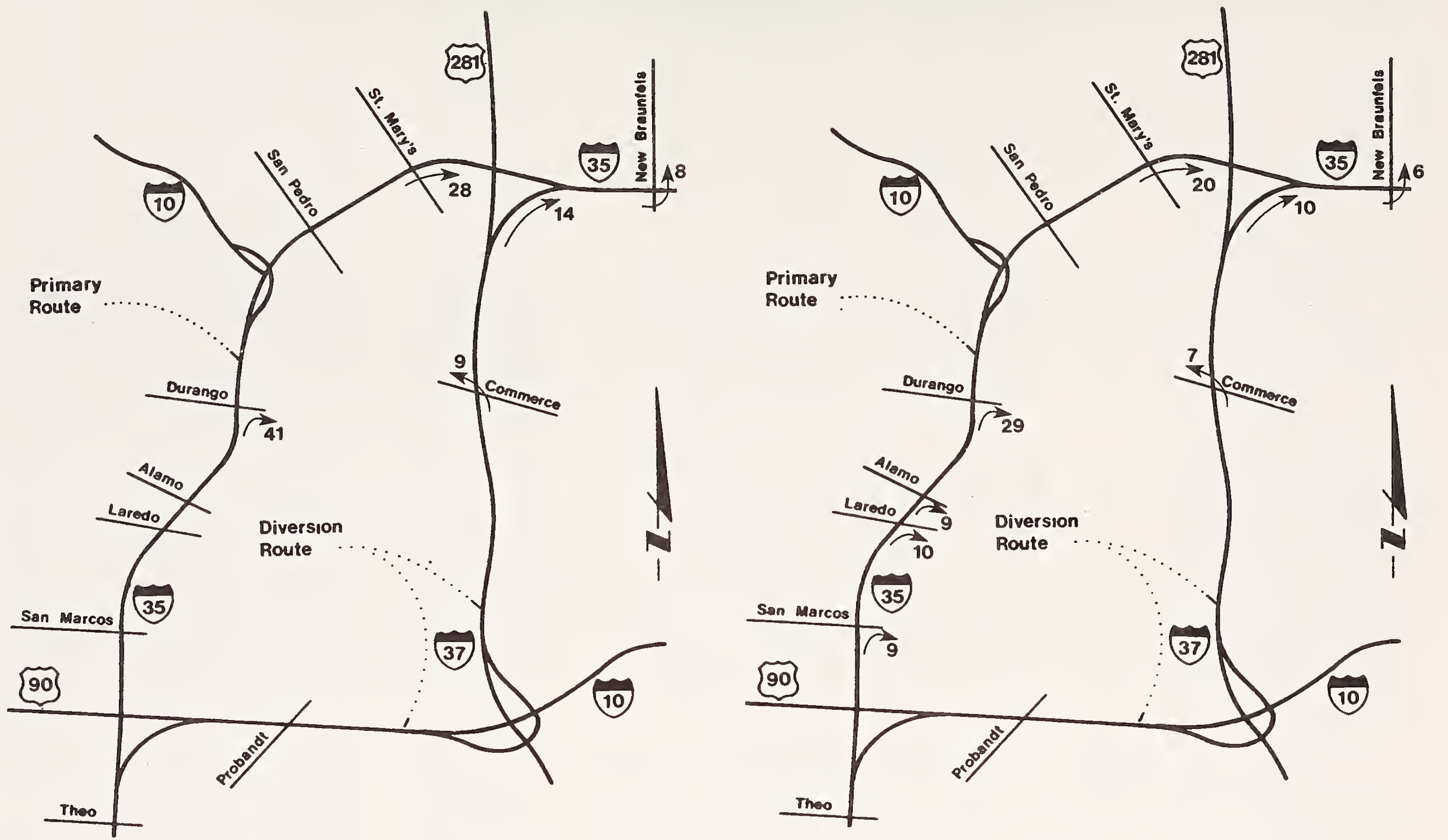


Figure 11 - Data Collection Locations for License Plate O-D Study



a. Original O-D Study

b. Follow-up O-D Study

Figure 12 - Percentages of Potential Diversion Audience

The results of this study were combined with the previous study results to obtain a better picture of the destinations (in terms of exit locations) of the potential diversion audiences (Figure 12b). Approximately 40% of the potential diversion audience had been assumed to be destined for downtown (Figure 12a). In actuality, almost 60% were bound for the CBD. (Note: the percentages shown in Figure 11 only include destinations of northbound I-35 drivers which were considered to be the potential audience for diversion. Routes such as eastbound and westbound I-10, westbound US-90, and northbound US-281 were not considered part of the potential audience).

Diversion Strategies

Following a review of the O-D patterns a committee consisting of SAPD, SDHPT, and TTI representatives mutually agreed to address only the traffic bound for downtown. The decision was based primarily on two considerations. First, the majority of incidents occurred during the peak period when O-D patterns showed a higher percentage of downtown-bound traffic. Secondly, it was reasoned that familiar drivers traveling thru the area would accept a message posted for downtown traffic as also applying to them.

It was mutually agreed by the three agencies that messages would be displayed only during incident conditions. Diversion messages would be displayed based on criteria of incident and end of queue locations (relative to the diversion point) set forth by the SAPD. Messages warning drivers of incidents would be displayed when diversion was not warranted. Estimates by the SAPD based on previous experiences indicated that the CMSs would probably be used for diversion about once every 1 to 2 months.

Messages

Once the diversion strategies were established, messages were developed using guidelines provided in the human factors Design Guide (2). Physical limitations on the matrix signs (i.e., 2 lines, 13 characters per line) required the use of compromise abbreviations or phrases, and extensive use of message chunking and sequential display mode.

Message length was limited primarily by the viewing time available at freeway speeds. The Design Guide reports that the 85th percentile legibility of 18-inch (45-cm) lamp matrix characters was approximately 650 feet (195 m). At 55 mph (88 km/hr) approximately 9 seconds of viewing time is available. The Design Guide suggests that about two seconds should be allotted for each display line consisting of about 16 characters. Therefore, about four lines of message per display was the practical maximum at the higher freeway speeds. Because the existing CMSs contained only two lines, the messages were chunked and designed to be displayed sequentially on the signs.

A portion of the resulting set of 120 messages is shown in Figure 13. The complete set of messages is listed in Appendix G. Each message line shown in the figures represents one sequence of the message.

Message Number	Sign 1	Sign 2	Message Number	Sign 1	Sign 2
1	SLOW TRAFFIC AHEAD BE PREPARED TO STOP		21	ACCIDENT AT COMMERCE	ACCIDENT AT CDMMERCE
2		SLOW TRAFFIC AHEAD BE PREPARED TD STOP	22	ACCIDENT AT COMMERCE	DDWNTDWN USE IH-1D / IH-37 AVOID MAJDR DELAY
3	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	23	ACCIDENT AT CDMMERCE DDWNTDWN USE IH-1D / IH-37	SLDW TRAFFIC AHEAD BE PREPARED TD STOP
4	ACCIDENT AHEAD BE PREPARED TO STOP	ACCIDENT AHEAD BE PREPARED TO STDP	24	SLDW TRAFFIC AHEAD BE PREPARED TD STOP	ACCIDENT AT CDMMERCE DOWNTDWN USE IH-1D / IH-37 AVOID MAJDR DELAY
5	ACCIDENT NORTH OF I-1DE	ACCIDENT NORTH OF I-1DE	25	ACCIDENT AT COMMERCE DOWNTDWN USE IH-1D / IH-37	ACCIDENT AT CDMMERCE DDWNTDWN USE IH-1D / IH-37 AVOID MAJDR DELAY
6	SLOW TRAFFIC AHEAD BE PREPAREO TO STOP	FWY BLOCKED AHEAD ALL TRAFFIC MUST EXIT IH-1D EAST--US 9D WEST	26	ACCIDENT AT DURANGO	ACCIDENT AT DURANGO
7	FWY BLOCKEO AHEAD ALL TRAFFIC MUST EXIT IH-1D EAST--US 90 WEST	FWY BLOCKED AHEAD ALL TRAFFIC MUST EXIT IH-1D EAST--US 90 WEST	27	ACCIDENT AT DURANGO	DDWNTDWN USE IH-1D / IH-37 AVDID MAJDR DELAY
B	FWY CLOSED AT IH-1DE--US-9D ALL TRAFFIC MUST EXIT	SLOW TRAFFIC AHEAD BE PREPARED TD STOP	2B	ACCIDENT AT DURANGO DDWNTDWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STDP
9	FWY CLOSED AT IH-1DE--US-9D ALL TRAFFIC MUST EXIT	FWY CLOSED AT IH-1DE--US-9D ALL TRAFFIC MUST EXIT	29	SLOW TRAFFIC AHEAD BE PREPARED TO STDP	ACCIDENT AT DURANGD DDWNTOWN USE IH-1D / IH-37 AVOID MAJDR DELAY
1D	DOWNTDWN USE IH-1D / IH-37 AVOID MAJOR DELAY	DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY	3D	ACCIDENT AT DURANGD DOWNTDWN USE IH-1D / IH-37	ACCIDENT AT DURANGO DOWNTDWN USE IH-1D / IH-37 AVOID MAJDR DELAY
11	ACCIDENT AT ST. MARYS	ACCIDENT AT ST. MARYS	31	ACCIDENT AT ALAMO ST.	ACCIDENT AT ALAMD ST.
12	ACCIDENT AT ST. MARYS	DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY	32	ACCIDENT AT ALAMO ST.	DOWNTOWN USE IH-1D / IH-37 AVDID MAJOR DELAY
13	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	33	ACCIDENT AT ALAMO ST. DDWNTDWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STDP
14	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT ST. MARYS ODWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY	34	SLOW TRAFFIC AHEAD BE PREPARED TO STDP	ACCIDENT AT ALAMO ST. DDWNTOWN USE IH-1D / IH-37 AVDID MAJOR DELAY
15	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-1D / IH-37	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY	35	ACCIDENT AT ALAMD ST. DOWNTDWN USE IH-1D / IH-37	ACCIDENT AT ALAMO ST. DDWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY
16	ACCIDENT AT IH-10 WEST	ACCIDENT AT IH-10 WEST	36	ACCIDENT AT LAREDO ST.	ACCIDENT AT LAREDO ST.
17	ACCIDENT AT IH-10 WEST	DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY	37	ACCIDENT AT LAREDO ST.	DOWNTDWN USE IH-1D / IH-37 AVOID MAJDR DELAY
18	ACCIDENT AT IH-1D WEST DOWNTOWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TD STDP	38	ACCIDENT AT LAREDO ST. DOWNTDWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TD STOP
19	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT IH-1D WEST DOWNTDWN USE IH-1D / IH-37 AVDIO MAJOR DELAY	39	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT LAREDD ST. DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR DELAY
2D	ACCIDENT AT IH-10 WEST DOWNTOWN USE IH-1D / IH-37	ACCIDENT AT IH-1D WEST DOWNTDWN USE IH-1D / IH-37 AVOID MAJOR DELAY	4D	ACCIDENT AT LAREDO ST. DWTN TRAFFIC USE I-1D/I-37	ACCIDENT AT LAREDO ST. DDWNTDWN USE IH-1D / IH-37 AVOID MAJOR DELAY

Figure 13 - Portion of Messages Developed

The inclusion of "AVOID MAJOR DELAY" in some of the messages resulted in an extension of the total display time (6 lines x 2 sec/line = 12 seconds) beyond the calculated 9 seconds. The longer messages were designed to be used only when traffic was moving at slow speeds due to the incident congestion. There was nothing to suggest this extension caused any problems. Accident locations referenced to the major cross-streets were included because previous experience (2) had indicated that this information was desirable to the driver.

A total of 120 messages were initially developed by TTI. The large number of message combinations was due primarily to the desire to display detailed incident location information.

CMS operation was initiated approximately eight months after the I-35 route change (changing of the static signs). The primary route is now US-81, while I-35 follows the I-10 and I-37 route around the CBD. Because "I-35" is a shorter and clearer term than "I-10/I-37", it was hoped that "I-35" could be used on the CMSs to identify the diversion route. A study conducted by TTI at downtown businesses indicated that local drivers had not changed their terminology after the route signing was changed. It was therefore decided that the use of "I-35" might be confusing to the local drivers. Data from that study and input from the local traffic agencies also indicated that the route should be referred to as "IH-10/IH-37".

Human Factors Evaluation of Messages

A limited human factors experiment was conducted to identify any needed improvements in the CMS messages with respect to clarity and meaningfulness. Specifically, ambiguities or confusion in the messages were sought, as well as indications whether thru traffic would respond to messages with "Downtown" displayed on the CMS. A total of 19 subjects were tested. All subjects were clerical or administrative personnel from the SDHPT and were no more familiar with dynamic signs than an average driver residing in San Antonio.

The experiment consisted of having the subject drive north on I-35 toward the CBD. Each subject was given one of two destinations: "Austin" or "Downtown". When the subject was within legibility distance of each CMS, flash cards were shown containing messages that would normally be displayed on the sign, and were held up for about the same amount of time as the displayed messages. Route choice and message reconstruction data, as well as pertinent comments, were recorded for each subject.

Of the 9 subjects given "DOWNTOWN" as a destination, 7 selected the diversion route. One of the two subjects who chose the primary route showed substantial confusion, more with driving on the freeway and general orientation than with the dynamic signs. That subject's recall of the dynamic sign message was very poor. The other subject said he knew exactly what to do, but in trying to follow the freeway signs ("like a good subject") he ended up on the wrong route. Three of the nine subjects indicated that the dynamic sign messages led them to believe that some mention would be made of "IH-37" on the overhead freeway guide signs as they approached the diversion point.

No Austin-bound subject chose the primary route, although one subject chose an arterial street route ("since he was not pressed for time."). Apparently this subject had already made his decision prior to seeing the CMS messages, as his recall of them was very poor. Two other subjects recalled only the action portions of the messages ("USE IH-10/IH-37").

Modification of Messages

Of the 19 subjects tested, 16 (84%) chose the correct route. In the administrators' opinions, two of the three errors in route choice were due to extenuating circumstances. Therefore, the basic messages appeared adequate to convey the appropriate diversion route to both downtown and thru motorists. The only consistent confusion appeared to be in the subjects' expectation of "IH-37" in some form on the freeway guide sign. Rather than attempt any kind of change to the freeway guide signs, the CMS messages were modified to read "IH-10 to IH-37" instead of "IH-10/IH-37".

Ten additional subjects were tested after the modifications. All ten chose the correct route and expressed no problem in understanding the messages. It was concluded that the modifications made were adequate.

Operational Control Procedures

As described previously, the decision was made by the operating agencies to place the CMS system under the sole control of the SAPD. Surveillance would be accomplished by regular freeway patrols and helicopter patrols. When an incident occurred, a patrol officer would radio the police dispatcher, who in turn would activate the CMSs. Operation of the system was incorporated within the normal working functions of existing SAPD personnel. No money was available for additional staff.

Recognizing the normally high demands placed on the dispatcher during an accident and the officers at an accident scene, it was necessary to develop a technique to streamline the effort involved in selecting and displaying messages. The technique had to be sensitive to the criteria of uniformity and consistency of messages displayed, while minimizing the time period required for the officers to select the appropriate messages. It was the intent that the message selection would be predetermined to the satisfaction of the SAPD and SDHPT supervisors and TTI. A formalized operational procedure would minimize the chance that messages would be selected by the police patrols based on unfounded criteria.

The approach developed was to assign a number to each message. Matrices similar to those shown in Figure 14 were developed for peak and off-peak periods and for complete and partial freeway blockage. Figure 14 illustrates the message selection matrix for peak period incidents which block one of the operating lanes. Matrices for peak period incidents blocking all lanes and for off-peak incidents are shown in Appendix G.

MESSAGE SELECTION
PATROL GUIDE
A.M. PEAK--1 LANE BLOCKED

TRAFFIC BACKUP

		North of I-10W	I-10W	Commerce	Durango	Alamo	Laredo	Stock Yards	I-10E	Theo	Division	Southcross
	North of I-10W	11										
	I-10W	11	16									
	Commerce	12	16	21								
	Durango	12	17	21	26							
	Alamo	12	17	22	26	31						
	Laredo	12	17	22	27	31	36					
	Stock Yards	12	17	22	27	32	36	41				
	I-10E	12	17	22	27	32	37	42	46			
	Theo	13	18	23	28	33	38	43	(46) 47*50	(53) 54*57		
	Division	13	18	23	28	33	38	43	(46) 47*50	(53) 54*57	(60) 61*64	
Sign 2	Southcross	14	19	24	29	34	39	44	(46) 48*51	(53) 55*58	(60) 62*65	(67) 68*69 70
Sign 1		15	20	25	30	35	40	45	49*52	56*59	63*66	68*69*70

Figure 14 - Example of Message Selection Guide

The matrices allowed the patrol officers and dispatchers to select numbers for the appropriate messages, based on the locations of the accident and the end of queue. Thus, there was no need for the officers to remember the message list, nor was it desirable that they individually request messages that would not provide a consistent and uniform display of message.

Scenario of Operation

The proposed scenario of operation was as follows: The initial activity of each day was for the dispatcher to make telephone contact with each sign to make sure it was operational and that it's timeclock was accurate. When an incident occurred, the response by the police was generally as follows:

1. Incident identified by SAPD air or ground unit,

2. Unit on scene notifies dispatcher of needed emergency services (ambulance, fire, wrecker, etc.),

3. Dispatcher contacts emergency services,

4. Unit scans the message chart for the appropriate message and message number and requests display of message by asking for the message number,

5. Unit begins to clear incident and move traffic,

6. Dispatcher telephones each sign and displays appropriate messages via teletype,

7. While in contact with each sign the dispatcher has the time of day and the message displayed (from the sign computer's internal clock) printed out on the teletype to provide an accurate, permanent record,

8. Unit notifies dispatcher when incident cleared, and

9. Dispatcher blanks signs and obtains a time and message turn-off record from each.

In addition to the teletype hard copy record, each officer requesting a CMS message completes an in-house report of conditions, time factors and messages requested. These data, along with the tape recordings made of selected dispatcher/officer communications, provided additional documentation of incident situations studied in this project.

Training of Operating Personnel

In May 1978, about two weeks immediately prior to the start of the CMS operations, approximately 60 field officers and dispatchers from the Traffic

Division of the SAPD were trained in the operation of the system and technique for selecting messages (see Figure 15). It was envisioned that field officers would most often be involved in message selection, and dispatchers in system operation. However, it was felt that if both were familiar with the other's tasks and responsibilities, coordination would be enhanced.

Field officers were trained to use information regarding time of day, number of lanes blocked, location of incident, and location of queue to determine appropriate message numbers from the matrices shown in Figure 13 and Figure G-2. Dispatchers were trained to activate the appropriate messages using the message numbers provided by the field officers. The several individual mechanical operations associated with activating a message received considerable attention in the initial training session.

About two weeks after the training sessions, a follow-up guide was prepared by TTI and distributed to the officers in each of the two groups. This guide emphasized: 1) confidence in the matrices and charts, 2) credibility (accuracy and timeliness), and 3) feedback to TTI on how well the system operates. A copy of the guide is presented in Appendix G.

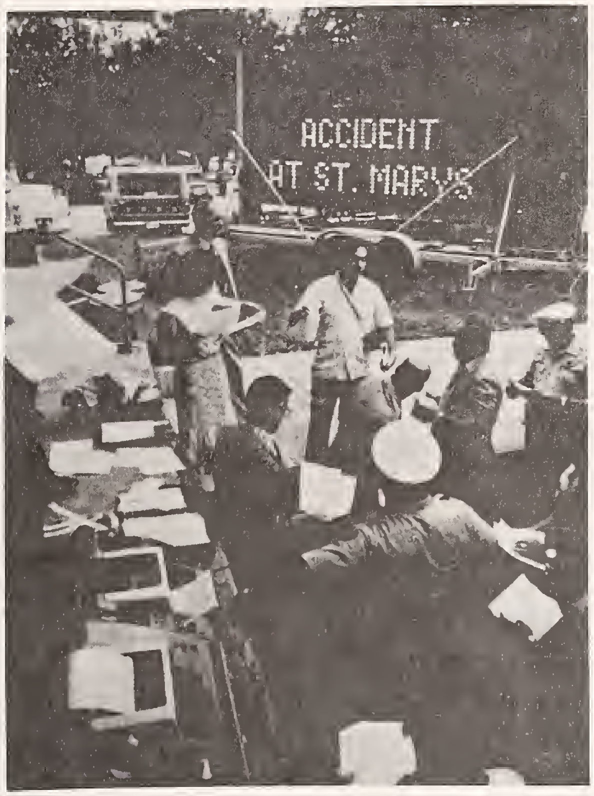


Figure 15 - Scenes from Police Training Sessions

Chapter 7

TRAFFIC DIVERSION

Objective

The primary objective of this phase of the research was to evaluate the effectiveness of the CMS system in diverting traffic to the diversion freeway route during incident conditions. A secondary objective was to develop a practical evaluation approach that can be implemented by city and state highway agencies in evaluating similar CMS systems considering the normal personnel and funding restraints.

Approach and Initial Observations

Collection of evaluation data posed several particularly difficult problems. License plate O-D surveys have been found to be a most accurate method of determining effectiveness of real-time displays. This type of study is particularly well-suited to predictable occurrences such as maintenance activities and special events (4, 5). However, the random nature of incidents precludes keeping a license plate data collection crew on standby. Therefore, a network of traffic volume counters was employed to obtain data that could be used in the evaluation.

Analysis of data from previous TTI studies in Dallas (5) had indicated that for point diversion during special events, changes in ramp volume at the diversion point were directly related to total diversion. These relationships were obtained by analyzing volume and license plate O-D data collected during weekend special events. It was hoped that similar results could be obtained in San Antonio from strategically locating counters on the primary and diversion routes. It was initially envisioned that volumes on the diversion freeway route would be expected to increase during intervals that the signs were on, while volumes on the primary route would reduce.

Traffic counters were installed on I-35 at one freeway location upstream from the diversion point, on three interchange ramps along the diversion route, and on the Durango Blvd. and Commerce Street exit ramps leading to the CBD to supplement the existing four permanent SDHPT counters located on the primary and diversion freeway routes (see Figure 16). The six new counters were modified to record volumes on punched tape at 5-minute intervals. The SDHPT permanent counters provided hourly counts. As a means of conserving on paper tape, battery and counter life, and data retrieval and processing, time-clocks were installed in the new counters to record volumes only from 7am to 7pm rather than continuously. Details of the 5-minute counters, their installation, data collection and processing, problems experienced and recommendations for future installations are discussed in Chapter 13 entitled,"Data Acquisition for Point Diversion".

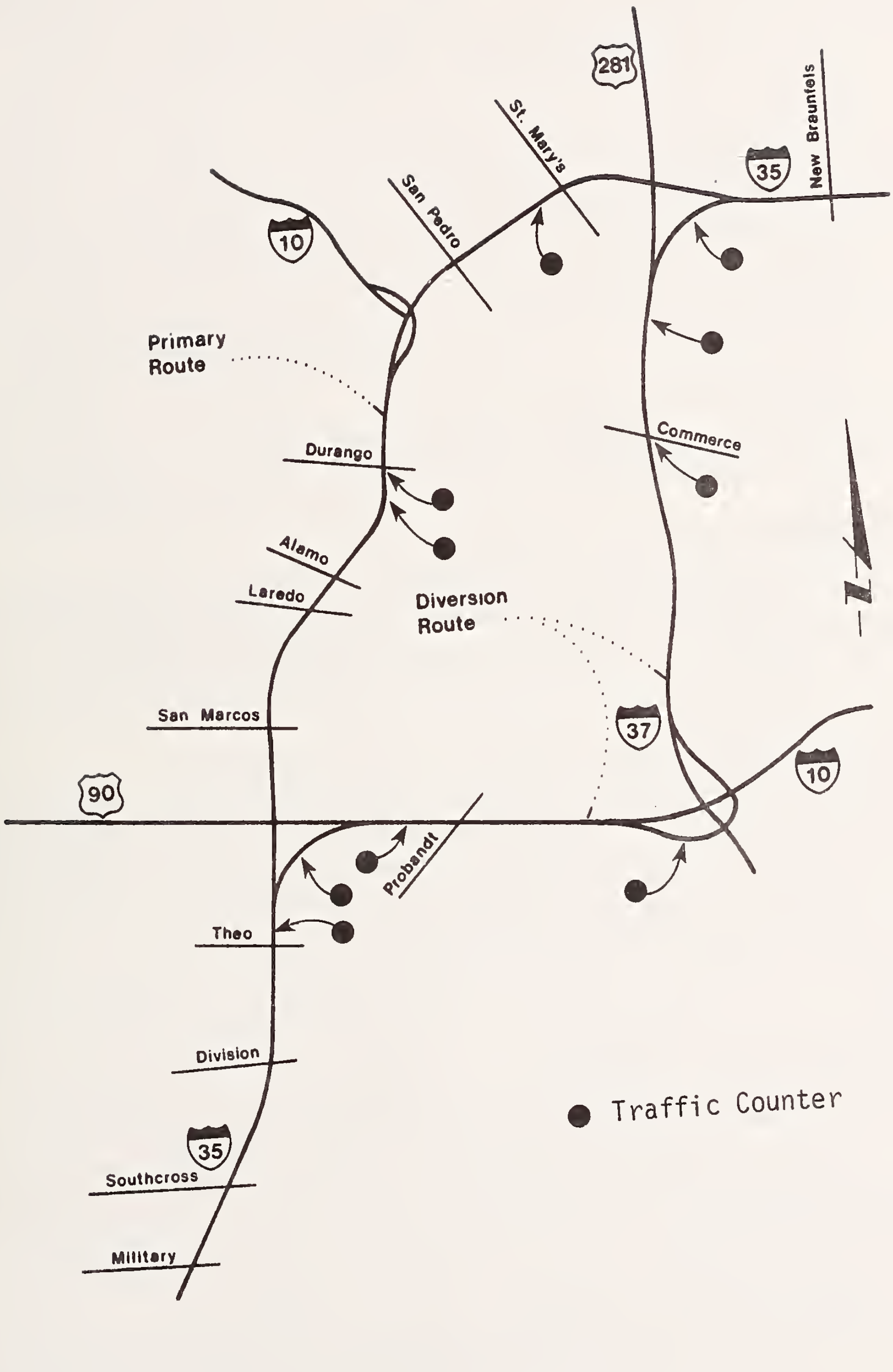


Figure 16 - Automatic Counter Locations

Initial plans were to evaluate the volume data collected from all 6 of the new automtic counters. It was expected that significantly high diversion rates would be reflected by lower volumes on the Durango ramp with corresponding increases on the diversion route interchange ramps (I-35/I-10E, I-10E/I-37 and I-37/I-35) and the Commerce ramp. Statistical analyses were to be performed on the data from each ramp to test whether there were differences during each incident period compared with periods immediately preceding and following it. Evaluations of data collected during selected incident cases coupled with a thorough assessment of available data resulted in changes to these plans. In addition to the counter problems discussed in Chapter 13, volume changes on the Durango, I-10E/I-37, I-37/I-35 and Commerce ramps were small in comparison to the total ramp volumes, Thus, it was difficult to determine whether the changes were due to the CMSs or to random variations in traffic demands. Also, the counting scheme employed did not provide a "closed" system whereby all input and output points were counted. With small changes in volumes on the ramps under study, it was difficult to trace origins with any certainty. For example, volume increases on the I-10E/I-37 ramp could originate from northbound I-35, eastbound US-90, and eastbound I-10. The amount of traffic originating from I-35 could not be determined.

It was reasoned, however, that if there indeed was diversion due to the CMSs, the volumes on the I-35/I-10E diversion ramp would be the most sensitive to any changes and, coupled with the freeway counts made at I-35 at Theo, would at least provide some trends indicating the effectiveness of the CMSs. Thus, efforts were then concentrated in analyzing the data from the diversion ramp and the freeway.

In contrast to the Dallas diversion studies (5) where congestion did not occur between the CMSs and the diversion ramp, queue buildup upstream from the diversion ramp due to incident bottlenecks, and peak period demand-capacity characteristics had to be considered. The effects of capacity-reducing incidents on freeway operating characteristics as they relate to the San Antonio study are briefly discussed in Appendix H.

The significant deduction from Appendix H is that the queue buildup had to be considered to accurately measure the diversion rate on the I-35/I-10E diversion ramp. It was important that motorists who read the CMSs and took the diversion route were accounted for even though they were trapped in the backup and their arrivals to the diversion ramp were delayed. Therefore, the analysis period for each incident must begin prior to the time when there was a signficant reduction in volumes upstream from the diversion ramp compared to normal days indicating traffic backup from the incident. The analysis period extends to the time when congestion clears and the freeway volumes on the incident day return to normal.

Experience (3, 4, 7) has shown that there is a significant number of drivers who leave the freeway (divert) upstream from their intended off-ramps whenever unusual congestion occurs even though they do not know the cause of the problem. This type of diversion is often referred to as "natural" diversion and in many cases can be quite high. Therefore, the amount of natural diversion had to be considered in order to more accurately evaluate the true

effects of the CMSs. The amount of natural diversion during incidents must be subtracted from the diversion occurring when the CMSs were used to determine the "added" effects of the CMSs.

The available data were studied to obtain volumes for the following situations:

1. for the incident when the CMSs were used (signed incidents),

2. for an incident occurring at approximately the same time of day and for which the CMSs were not used (unsigned incidents), and

3. normal volumes for a comparable period which consisted of the average of two or three similar days (same day of week) within two or three weeks of the incident day.

A potential case study incident was identified when volumes were available for all three situations. Certain criteria had to be met before the data from a signed incident day could be used in the analysis. These were as follows:

1. The incident must occur at or downstream from the diversion point;
2. The CMS must be activated, and
3. Information concerning the incident time and location and the type and time of message must be available.

Details of the data acquisition are discussed in Chapter 13.

To develop a data base for the amount of natural diversion for each case study incident, attempts were made to find a day when the CMSs were not used during an incident that occurred at approximately the same time of day, weekday, and within two or three weeks from the case study incident. As would be expected, there was some difficulty in finding such data for all case study incidents. However, as a minimum, data were found for incidents occurring during the same year and month and reasonably close to the same time of day. In most cases, data for unsigned incidents were available on the same weekday as the case study incidents.

Normal traffic volume data base was developed for each case study incident by averaging data from two or three days obtained from the same time period, weekday, month and year as the case study incident. Care was exercized to insure that non-incident days were selected.

The analysis process used in this project to evaluate the diversion influenced by the CMSs is illustrated in Figure 17. Five-minute freeway volumes obtained from the automatic traffic counters located on I-35 at Theo (just upstream from the I-35/I-10E diversion ramp) and on the diversion ramp are shown plotted for one of the case study incidents. Similar data for the other six case study incidents are presented in Appendix I.

An examination of the freeway volumes in Figure 17 shows that at time t_0 the volumes are approximately the same for all three of the situations.

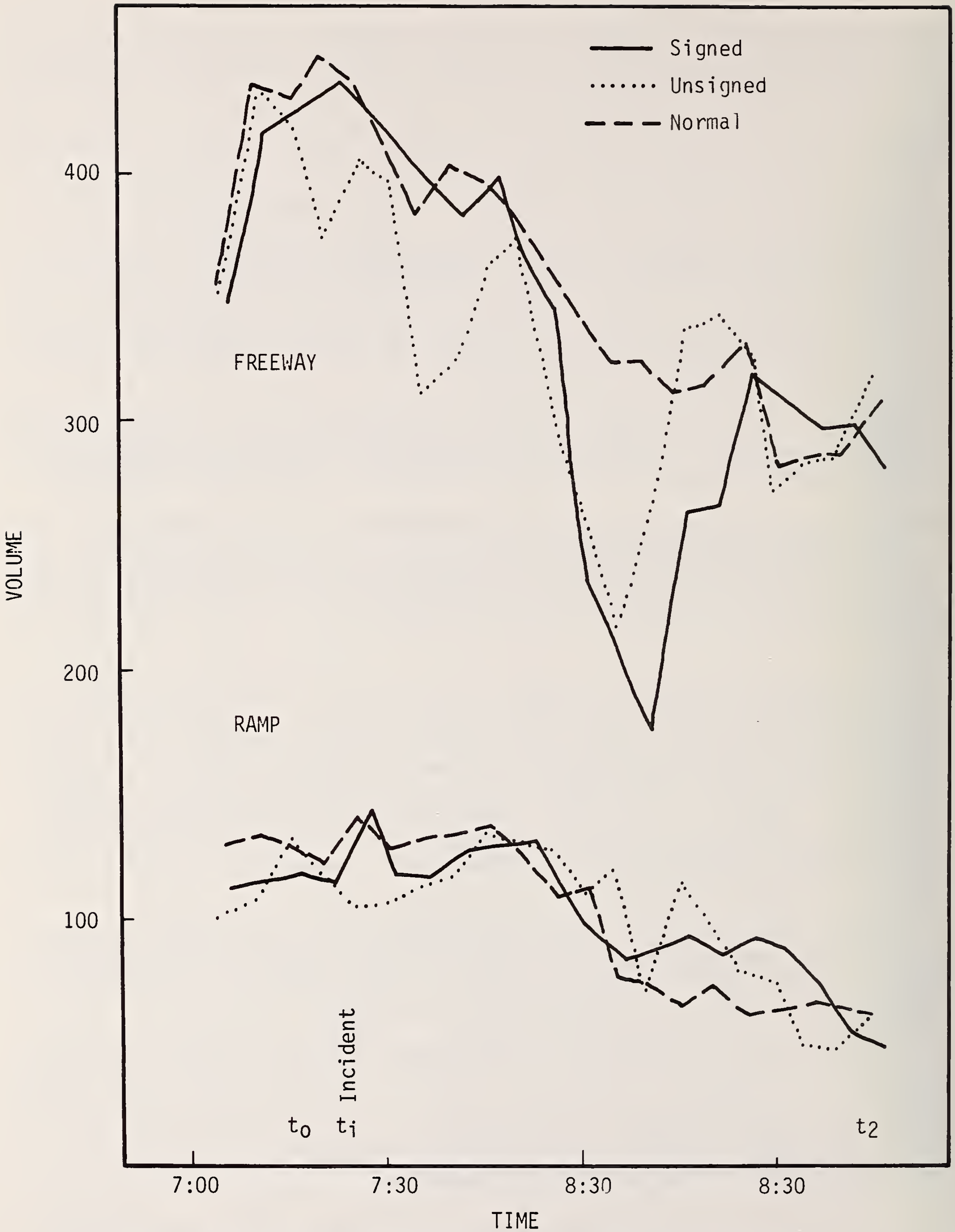


Figure 17 - Five Minute Volumes for Diversion Analysis

After the incident at time t_i, traffic was stored due to the demands exceeding the incident bttleneck capacity. As the queue propagated upstream and passed through the I-35/I-10E interchange and then over the freeway detectors at Theo Ave., the volumes significantly reduced. The drop in volumes represents the queue buildup on the freeway. When this occurred, drivers destined for the I-35/I-10E diversion ramp (both those who normally use the ramp and those who intended to use it because of the congestion and CMS messages) were delayed in both time and space. When the incident vehicles were removed from the freeway the capacity increased and the buildup dissipated. This is illustrated by the volume increase at the freeway counter station. Once the queue dissipated from the interchange area, the volumes returned to those normally expected for the particular time of day. The volumes for all three situations are approximately equal at time t_2.

In order to account for the traffic volume using the I-35/I-10 diversion ramp for all three situations, the analysis included the time period from t_0 to t_2.

Because traffic demands are likely to be different for each of the three situations due to normal traffic variations, a direct comparison of volume changes on the diversion ramp for each of the three situations is inappropriate. To account for normal traffic variations, volumes on the I-35/I-10E ramp were converted to percentages of the I-35 freeway demand volumes for further analysis. A basic assumption underlining this approach is that the percentage of I-35 drivers who would normally use the I-35/I-10E ramp between times t_0 and t_2 is the same each non-incident day. Increases in traffic percentages on the diversion ramp would be attributed to the incident and the CMSs.

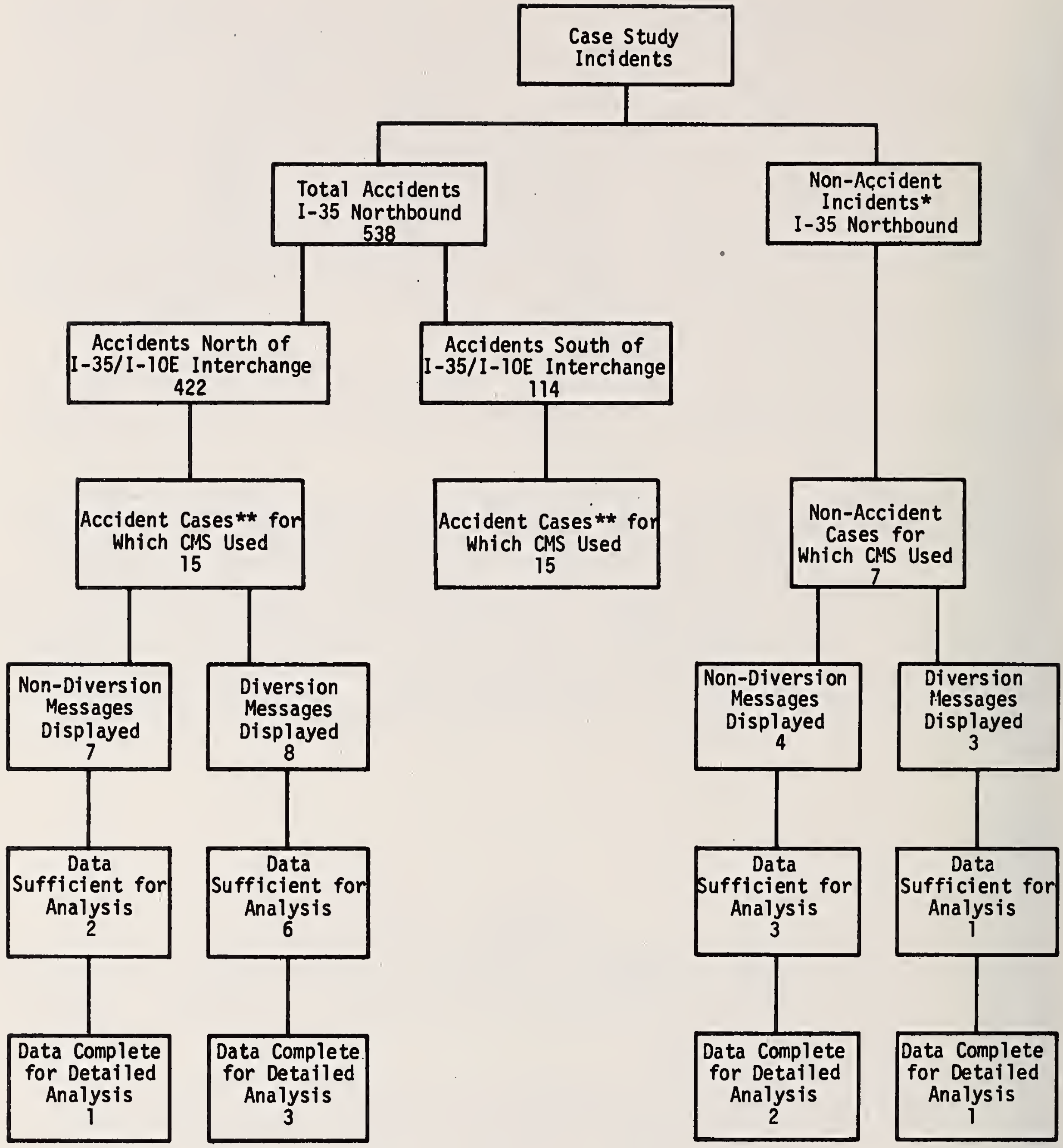
Results

Case Study Incidents

Figure 18 is a summary of the accidents and other incidents, CMS usage, and resulting case study incidents that were available for study. Details of the CMS usage are discussed in Chapter 8, "Perceived Effectiveness of the CMS System."

As shown in Figure 18, 536 accidents occurred on northbound I-35 in the study area during the two-year study period; 422 accidents occurred at or downstream of the diversion point. The CMSs were used during 15 of these accidents. Diversion messages were displayed 8 times and warning messages during 7 incidents. Further analysis revealed that the necessary data for more detailed analysis was available for only 4 case study incidents. Diversion messages were used during 3 of these cases and a warning message during the remaining one case.

The CMSs were also used during 7 non-accident incidents (e.g., spilled load, high water, stalled vehicles, etc.). The data sets were complete for 3 of these cases. Therefore, data sufficient for detailed analysis of diversion



*Spilled load, high water, stalled vehicle, etc. Total number of such incidents are not available.

**In some cases two accidents occurred.

Figure 18 - Summary of Accidents and Other Incidents

rates were available for only 7 case study incidents--4 accident cases and 3 non-accident cases.

Results of the seven case study incidents are summarized in Table 5. Included in the Table is the percent of northbound I-35 drivers (counted at Theo Ave.) that used the diversion ramp: 1) during normal conditions, 2) during an incident when the CMSs were not used (unsigned incident), and 3) during the incident when the CMSs were used (signed incident). Also shown are the results of the Z-test of Proportions analyses (8) testing differences between each of the three situations.

The results reveal that for five of the seven cases (#1, 2, 5, 6, & 7), the percent of traffic using the diversion ramp during the unsigned incidents (natural diversion) was significantly higher ($p<.05$) than normal (on days when incidents did not occur). In four (#1, 2, 5, & 6) of these cases, the diversion rate during the signed incident was also significantly higher ($p<0.5$) than normal. Of the five incident cases in which either the unsigned or signed incidents yielded greater diversion rates than what would normally be expected, only two of the cases had significantly higher diversion rates for the signed incident than the unsigned incident; in two other cases the unsigned incident yielded higher diversion rates than the signed incident. In the remaining case the diversion rates were the same for both the signed and unsigned incidents.

Combining the data for all seven incidents, the results revealed that on the average 25% of the northbound I-35 traffic used the diversion ramp during the normal periods, whereas 27% and 28% of the traffic used the ramp during the unsigned and signed incidents. Statistical analyses indicated that the diversion during the unsigned incidents was significantly higher ($p<.05$) than normal and the diversion during the signed incidents was significantly higher than both the normal periods and the unsigned incidents.

An examination of Table 5 shows that in only one of the case study incidents did the amount of the percentage increase in diversion appear to be high numerically. During incident case #1 when the CMSs were operating, 32% of the traffic used the diversion ramp. This was significantly higher than both the 22% diversion during the unsigned incident and 19% during the normal period. The incident, however, was different from the others. The accident occurred on the median lane just upstream from the diversion ramp. Blockage of the lane at that point may have indirectly caused several drivers in the right lane to be trapped because of the lane drop and forced onto the diversion ramp. This may have resulted in the relatively high percentage of traffic using the ramp in comparison to the unsigned and normal periods.

An analysis of the six incident cases excluding #1 revealed diversion percentages of 25%, 27%, and 27% for the normal, unsigned, and signed incidents. The 2% increase in diversion during the signed and unsigned incidents was significantly higher than normal ($p<.05$). However, as the data show, there was no difference in diversion rate between the signed and unsigned incidents. Therefore, on the average, use of the CMSs during the incidents did not result in greater use of the diversion route than the amount of

TABLE 5

RESULTS OF CASE STUDY INCIDENTS

Incident No.	Incident Date	Incident Time	Incident Location	Message Type	Analysis Period	Percent N.B. I-35 Using Diversion Ramp		Test of Signifi- nance*
1	Thursday, 8/17/78	8:45 a.m.	I-35 at I-35/I-10 E Interchange	Diversion	8:50-9:50 a.m.	Normal :	19	
						Unsigned Incident:	22	a
						Signed Incident :	32	a,b
2	Tuesday, 10/10/78	6:45 a.m.	I-10W at Colorado	Diversion	7:30-9:30 a.m.	Normal :	24	
		8:00 a.m.	I-35 at I-35/I-10 Interchange	Diversion	7:30-9:30 a.m.	Unsigned Incident:	27	a
						Signed Incident :	29	a,b
3	Friday, 9/29/78	5:25 p.m.	I-35 at Commerce	Diversion	5:25-7:00 p.m.	Normal :	25	
						Unsigned Incident:	24	
						Signed Incident :	25	
4	Saturday, 10/21/78	2:25 a.m.	I-35 at Alamo	Diversion	2:20-3:30 p.m.	Normal :	22	
						Unsigned Incident:	22	
						Signed Incident :	22	
5	Monday, 10/2/78	8:00 a.m.	I-35 at Alamo	Warning	7:50-8:50 a.m.	Normal :	24	
						Unsigned Incident:	29	a
						Signed Incident :	30	a
6	Wed., 10/25/78	7:35 a.m.	I-35 at Durango	Warning	7:30-8:30 a.m.	Normal :	27	
						Unsigned Incident:	32	a,c
						Signed Incident :	29	a
7	Thursday, 11/2/78	7:35 a.m.	I-35 at Stockyards	Warning	7:25-8:30 a.m.	Normal :	28	
						Unsigned Incident:	31	a,c
						Signed Incident :	28	
			ALL 7 INCIDENTS COMBINED			Normal :	25	
						Unsigned Incident:	27	a
						Signed Incident :	28	a,b
			ALL INCIDENTS EXCLUDING #1			Normal :	25	
						Unsigned Incident:	27	a
						Signed Incident :	27	a

*a = Significantly greater than Normal conditions
b = Significantly greater than Unsigned Incident conditions
c = Significantly greater than Signed Incident conditions

natural diversion that occurred without the signs. In addition, although the 2% increase is statistically significant, it is insignificant from a freeway operations standpoint.

The data were further analyzed to determine whether diversion rates were affected by the period of day when the incidents occurred. Table 6 is a summary of the case study incidents grouped by peak and off-peak periods.

The results reveal that diversion rates were significantly higher during the unsigned and signed peak period incidents in comparison to what would normally be expected. However, no differences were found in the diversion rates during the off-peak periods.

A review of Table 6 also reveals that when incident Case #1 is excluded from the peak period incident analysis, the diversion during the signed incidents was higher than normal, but was no different than the natural diversion that takes place during unsigned incidents.

Discussion of Results

Analysis of the effectiveness of the CMSs was based solely on a freeway-to-freeway point diversion concept. Funds were not available and no attempts were made to evaluate the traffic diversion to other arterial routes induced by the CMS messages. During conversations with a few local drivers who commute to work on northbound I-35, the drivers stated that, when accident messages were displayed on the CMSs, they oftentimes left the freeway via one of the off-ramps upstream from the I-35/I-10E interchange (diversion ramp) and took another route to work. These alternate routes were more convenient than the diversion route recommended by the CMSs. Diversion to other arterial routes was also frequently noticed by freeway patrol officers. Thus, there was more diversion within the system than the data indicated.

These observations suggest that in contrast to diversion of special event traffic when drivers are willing to use the recommended alternate route (5, 9), "point diversion" during accidents in an urban area may be a misnomer.

Special event traffic generally is destined to the same place and, in many cases, to the same parking facility. In contrast, the destinations of commuters going to the CBD are scattered throughout the downtown area. Thus the route recommended by the CMSs may be the most logical one, but may not necessarily be the most convenient for many of the drivers. They may elect to choose their own routes based on the time of day, location of the accident, the degree of freeway congestion, etc. Or, they may decide to remain on the freeway for one reason or another, including simply a reluctance to use another route.

Driver response to real-time information in San Antonio appeared to be similar to that experienced in Dallas (4), Los Angeles (3), and Minneapolis (10). Rather than diverting via one major ramp when they were notified of an incident or when they encountered unusual congestion, drivers who diverted

TABLE 6

CASE STUDY INCIDENTS SUMMARIZED BY TIME PERIOD

Incident Numbers	Period	Percent N. B. I-35 Using Diversion Ramp	Test of Significance*
1, 2, 5, 6, 7	Peak	Normal : 25	
		Unsigned Incident: 28	a
		Signed Incident : 29	a,b
2, 5, 6, 7**	Peak	Normal : 26	
		Unsigned Incident: 29	a
		Signed Incident : 29	a
3, 4	Off-Peak	Normal : 24	
		Unsigned Incident: 23	
		Signed Incident : 24	

* a = Significantly greater than Normal conditions
b = Significantly greater than Unsigned Incident conditions

**Excludes Incident #1.

tended to use exit ramps leading to routes most convenient to them. In retrospect, analyzing the San Antonio CMS installation as an incident management system rather than a point diversion system would have most likely resulted in a more complete description of traffic diversion. The limited scope of the study focused attention on the freeway-to-freeway diversion. The results strongly indicate that agencies evaluating similar systems should monitor all the off-ramps that are likely to be used. Agencies should not be misled and restricted in their evaluation approach because of terminology; they should develop an evaluation approach that will assess the full impact of the CMS system if they can afford to do so.

Chapter 8

PERCEIVED EFFECTIVENESS OF THE CMS SYSTEM

Background

During the first year of operation, two problems arose that had an impact on the CMS evaluation studies. First of all, there were numerous problems with the automatic counters which limited the amount of useful data for estimating the amount of freeway-to-freeway diversion attributable to the CMSs. (See Chapter 13 for details.) Secondly, the police patrol officers and the police dispatchers who operated the CMSs encountered difficulty in using the operational control procedures (i.e., selection of sign messages based on the location of accident and length of backup) developed by TTI, SDHPT, and SAPD. As a result of discussions with the SAPD, the 120 messages in the original CMS library were reduced to 7. (See Appendix J for details.)

The potential of a small sample size due to counter malfunctions prompted the research team and the San Antonio Corridor Management Team to seek alternative measures of effectiveness. It was the feeling of police administrators and some of the patrol officers that the CMSs were effective in improving safety in the accident area where the officers and involved motorists were located. They believed that by keeping drivers informed of freeway conditions, the CMSs help to relieve driver frustration and anxiety. As a result, drivers are less "hostile" when passing an officer directing traffic. It was their opinion that regardless of whether the CMSs divert a considerable amount of traffic, these intangible effects are realized.

Administrators from the SAPD stated that the field patrol officers would use the CMSs if they felt the signs were helpful in controlling traffic on the freeway. Although the intangible benefits of less driver frustration and anxiety cannot be measured directly, it was speculated that perceived benefits can be assessed by measuring police usage of the CMSs. Increased usage during the second year would indicate positive feelings about the system by the police officers. As previously mentioned, and discussed in Appendix J, operation of the system was simplified by TTI at the beginning of the second year of operation by reducing the number of messages and improving the operation control procedure.

Objective

The objective of this portion of the research was to measure the perceived benefits of the CMSs by evaluating the CMS usage during the first and second years of operation.

Approach

The approach used to assess the perceived effectiveness of the CMS system was to compare the utilization of the CMSs during accidents and the attitudes of the police freeway patrols and dispatchers between the first and second year of operation.

Accident records and CMS utilization information, discussed in detail in Chapter 13, were compiled during the two years. In addition, interviews were conducted with police patrol officers and dispatchers at the end of each year of operation.

Results

Tables 7 and 8 list the number of accidents and times the CMSs were used by month during each of the two study years. The data are also shown plotted in Figure 19 in terms of percentages.

The results show that there was a significant reduction in the use of the CMSs during the second year of the study. The signs were used only 6 times (0.5 times per month) during the second year in comparison to 26 times (2.2 times per month) during the first year of operation. Considering the use per accident, Tables 7 and 8 show that during the second year the signs were used for 2.4% of the accidents in comparison to 9.0% of the accidents the first year.

The results were disappointing considering the fact that the initial library of CMS messages were reduced from 120 to 7 to simplify the operations following interviews with police patrol officers and dispatchers after the first year of operation. However, frequency of sign usage during the second year (0.5 times per month) was not out of line with earlier estimates. SAPD administrators predicted prior to the CMS pilot program that based on their experiences with the types of accidents on I-35, the signs would most likely be used an average of once every 1 to 2 months. The disappointment, therefore, stems from the indications of greater interest and desire to use the signs during the first year (even though the rate during the second year was in line with earlier SAPD predictions) and indications of reduced interest during the second year.

Interviews with SAPD administrators indicated the following reasons for the reduced use:

1. Difficulties with existing hardware system;
2. Turnover and reassignment of SAPD personnel;
3. Shift rotations; and
4. Reduced direct contact between SAPD administrators and the dispatchers and patrol officers.

The CMS hardware system was primarily designed for research and is not ideally suited for operations by non-technical personnel. This potential

TABLE 7

CHANGEABLE MESSAGE SIGN USE
DURING FIRST YEAR

MONTH	Number of Accidents	Frequency of Sign Use for Accidents
June '78	15	2
July '78	29	0
August '78	26	4
September '78	33	4
October '78	29*	4
November '78	25	1
December '78	32	2
January '79	26**	4
February '79	22	2
March '79	26	2
April '79	17	0
May '79	10	1
	290	26

*Includes one I-10W at Colorado Accident

**Includes one SB I-35 Accident at Nogolitos

Average number of accidents per month = 24.2

Average sign use per month = 2.2

Percent of accidents for which signs were used = 9.0%

TABLE 8

CHANGEABLE MESSAGE SIGN USE
DURING SECOND YEAR

MONTH	Number of Accidents	Frequency of Sign Use for Accidents
June '79	24	0
July '79	22	3
August '79	21	0
September '79	23	0
October '79	23	0
November '79	16	0
December '79	12	1
January '80	13	1
February '80	21	0
March '80	17	1
April '80	26	0
May '80	29	0
	248	6

Average number of accidents per month = 20.7
Average sign use per month = 0.5
Percent of accidents for which signs were used = 2.4%

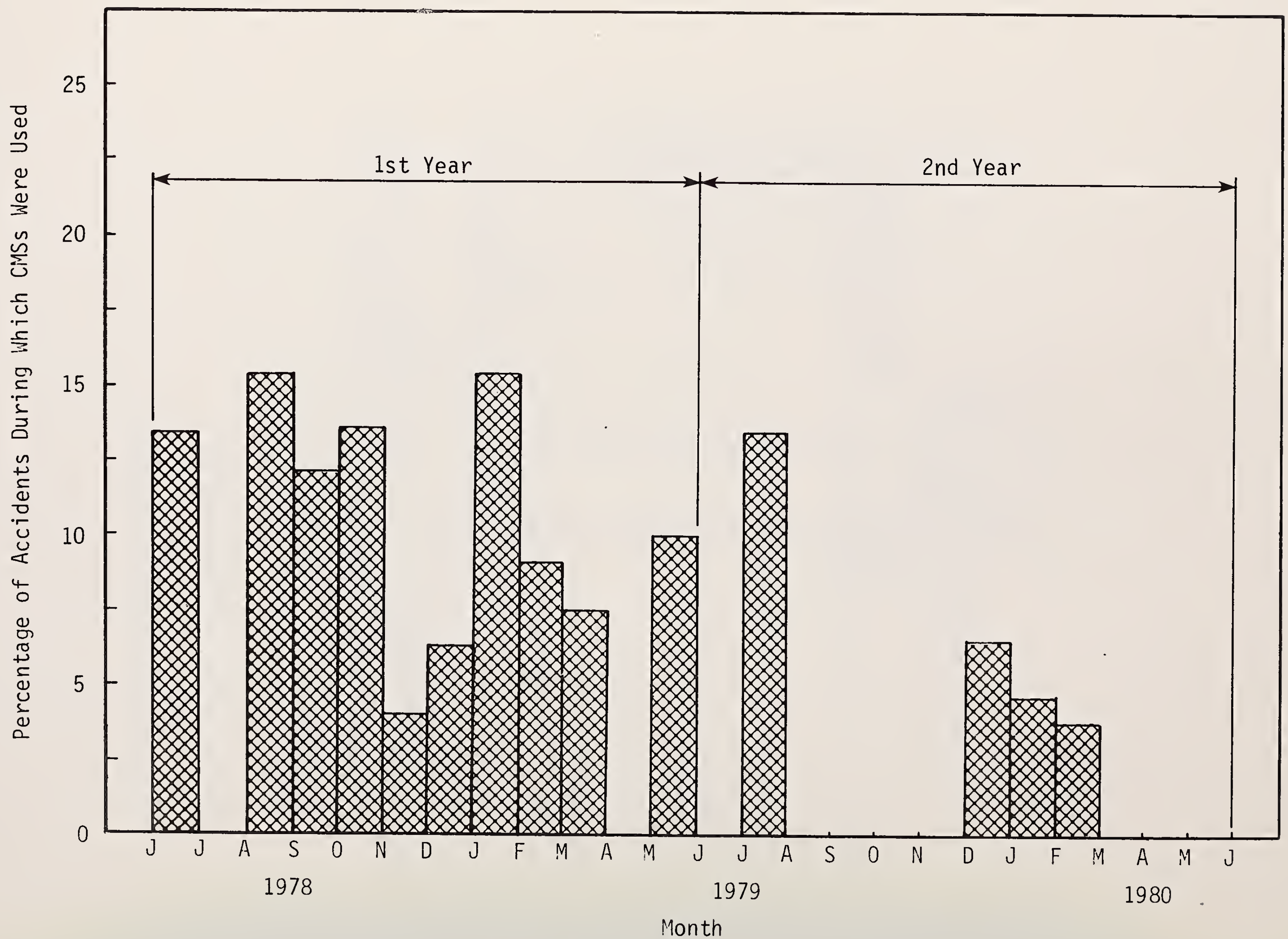


Figure 19 - Use of Changeable Message Signs on I-35 in San Antonio

problem was recognized initially by TTI, SDHPT, and SAPD, but it was hoped that some of the difficulties could be resolved. Details of the hardware system, problems and recommendations, are discussed in Chapter 13, "Data Acquisition for Point Diversion".

Normal turnover and reassignments resulted in a situation where some of the police officers were not familiar with the objectives, design and operation of the CMSs. In retrospect, the research project should have been funded to periodically furnish training to the newer officers.

The dispatcher/CMS operators were on rotating shifts. Use of the CMSs was highest during the morning peak periods. The dispatchers, who became somewhat familiar with operating the CMSs, would switch shifts and not return to the morning shift until two months later. The complexity of the hardware resulted in the operator being more reluctant to use the signs when he returned. CMS operating procedures were forgotten during the long periods away from operating the signs.

Dispatchers switching from the night to the morning shifts seemed to forget the operating procedures because of the extended period between the training school and actual hands-on operations.

Probably the factor which had the greatest impact on the reduced use of the CMSs during the second year resulted indirectly from the energy situation. As was the case with other agencies, the City of San Antonio was hit by higher fuel costs. As a conservation measure, the City Manager issued a directive in early June 1979 stating that official vehicles were no longer allowed to be driven to and from home. Radio communication between the police administrators and supervisors with the dispatchers and freeway patrol officers during the first year requesting the use of the CMSs was a positive indication and assurance of the importance of the system. The absence of radio communications between the administrators and supervisors and patrol officers, according to SAPD officials, was an influencing factor in the reduced use of the CMSs during the second year.

PART IV

CHANGEABLE MESSAGE SIGNS DURING FREEWAY MAINTENANCE OPERATIONS

Chapter 9

INTRODUCTION

Objectives

The objective of this portion of the research was to evaluate the effectiveness of CMSs during urban freeway maintenance operations necessitating lane closures. Specifically, the objectives were to determine the effectiveness of the CMSs in accomplishing the following:

1. encouraging drivers to vacate the closed lane farther upstream from the cone taper, and

2. encouraging thru drivers to divert to an alternate freeway route.

Background

As previously discussed, there is a significant amount of natural diversion whenever unusual congestion occurs on an urban freeway. Results obtained in the Dallas CMS studies (4) revealed that during freeway maintenance operations, informational messages about roadwork (e.g., ROADWORK AT OXFORD AVE.) increased diversion off the freeway between 5.1% and 7.4% (expressed as a percent of upstream demand) in comparison to the natural diversion that was expected without a CMS message. Diversionary messages (i.e., drivers instructed to exit freeway) increased diversion by an additional 2% in comparison to the informational messages.

The location of CMSs on I-35 in San Antonio provided an opportunity to observe lane distribution patterns to evaluate how quickly drivers vacate the closed lane, and to study the effectiveness of the CMSs in diverting freeway traffic to an alternate freeway route around the work zone. In contrast with the Dallas studies where the drivers were not told which exit ramps to use, San Antonio drivers were instructed to use the diversion freeway route.

Study Development

As previously mentioned, the study section of old I-35 north of the diversion route and adjacent to the CBD is two lanes in each direction. Closure or blockage of one lane results in relatively severe congestion during the peak period and off-peak daylight hours. Consequently, maintenance in this freeway section is infrequent, and when required, is generally performed during the night and early morning hours.

Because of the large size of field study personnel required to conduct the CMS studies and the infrequency of maintenance on the I-35 freeway section, close coordination was necessary between the researchers and the Maintenance Engineer and Area Supervisor so that study preparations could be made

when maintenance was anticipated. As it turned out, the only maintenance in the study area during the research contract period to the knowledge of TTI, was performed on March 11th, 17th, and 18th, 1980.

Pavement repairs on I-35 at Division (south of the diversion route) on March 11th between 9:30am and 2:00pm provided an opportunity to evaluate driver reactions (i.e., lane changes) to lane closure information displayed on a CMS. The inside lane of the two-lane section north of the I-35/I-10E interchange was closed on March 17th and 18th during median guardrail repairs and provided an opportunity to study freeway-to-freeway diversion during maintenance operations. The maintenance was performed between the hours of 9:00pm and 3:00am. The March 11th lane change study and the March 17th and 18th diversion studies are discussed in the next two chapters.

Chapter 10

LANE-CHANGE STUDY

Site Description

A freeway schematic illustrating the location of the work zone and the types of traffic control devices is shown in Figure 20. Because of the relative locations of the CMSs to the work zone, only the CMS near the Southcross Avenue pedestrian crossing was used during the study. Messages on the CMS at the Division pedestrian crossing would serve no useful purpose because it was too close to the lane closure.

Study Approach

Lane distribution counts were made by observers at eight freeway locations--one station upstream from the CMS, one at the CMS, and six downstream. In addition, traffic volumes thru the work zone were counted in an attempt to measure the work zone capacity. (Volumes, however, never reached capacity flow).

In order to assess the effectiveness of the CMS in encouraging drivers to vacate the closed lane, the sign was turned on and off alternately at approximately 20-minute intervals between the hours of 9:50am and 1:50pm. The field data show that the CMS was activated a total of 124 minutes and was in the off position for 127 minutes. The CMS message was displayed in two parts and read: ROADWORK AT DIVISION/LEFT LANE CLOSED. Each message part was displayed alternately for four-second intervals.

Two vehicles were driven thru the study area--one to mark the time when the sign message was turned on and the other when it was turned off. As the drivers reached each count station they alerted the observers by radio who would then record the time and volumes. This technique, used successfully by TTI during diversion studies in Dallas (5), "opens" and "closes" each study period and separates those drivers who had an opportunity to read the CMS message from those who did not.

Results

Figure 21 is a comparison of the hourly volumes on each ramp and freeway section during periods when the CMS was displayed and in the off status. A review of the data shows that the volumes during both periods were comparable. Therefore, differences in volumes was not an influencing factor in the results.

One MOE is the percent of traffic that remains in the closed median lane as traffic progresses toward the cone taper. If the CMS is effective, it is expected that a greater percentage of drivers would leave the median lane (and

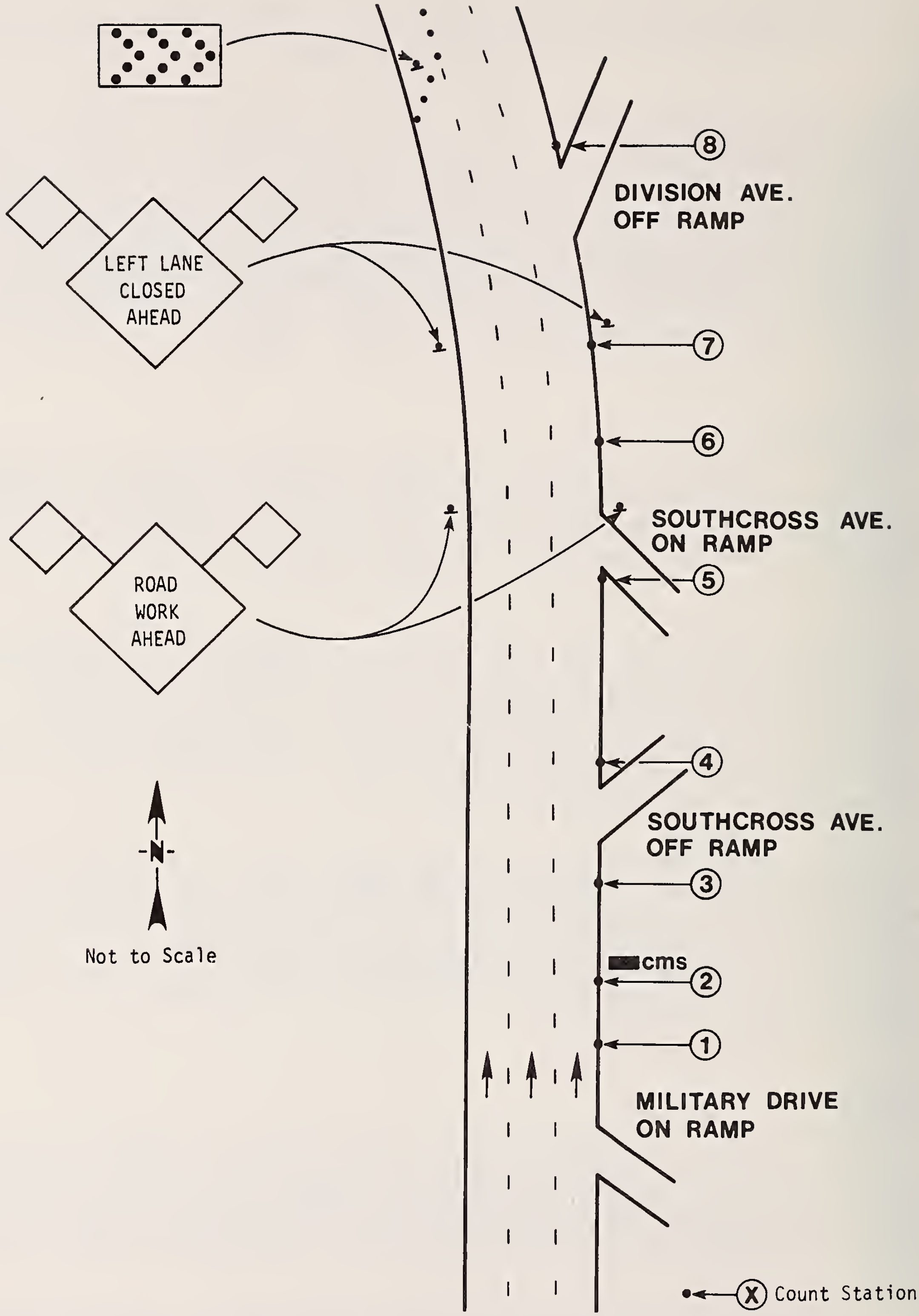


Figure 20 - Schematic of Work Zone (March 11, 1980)

Note: CMS "off" shown without parenthesis.

CMS "on" shown with parenthesis.

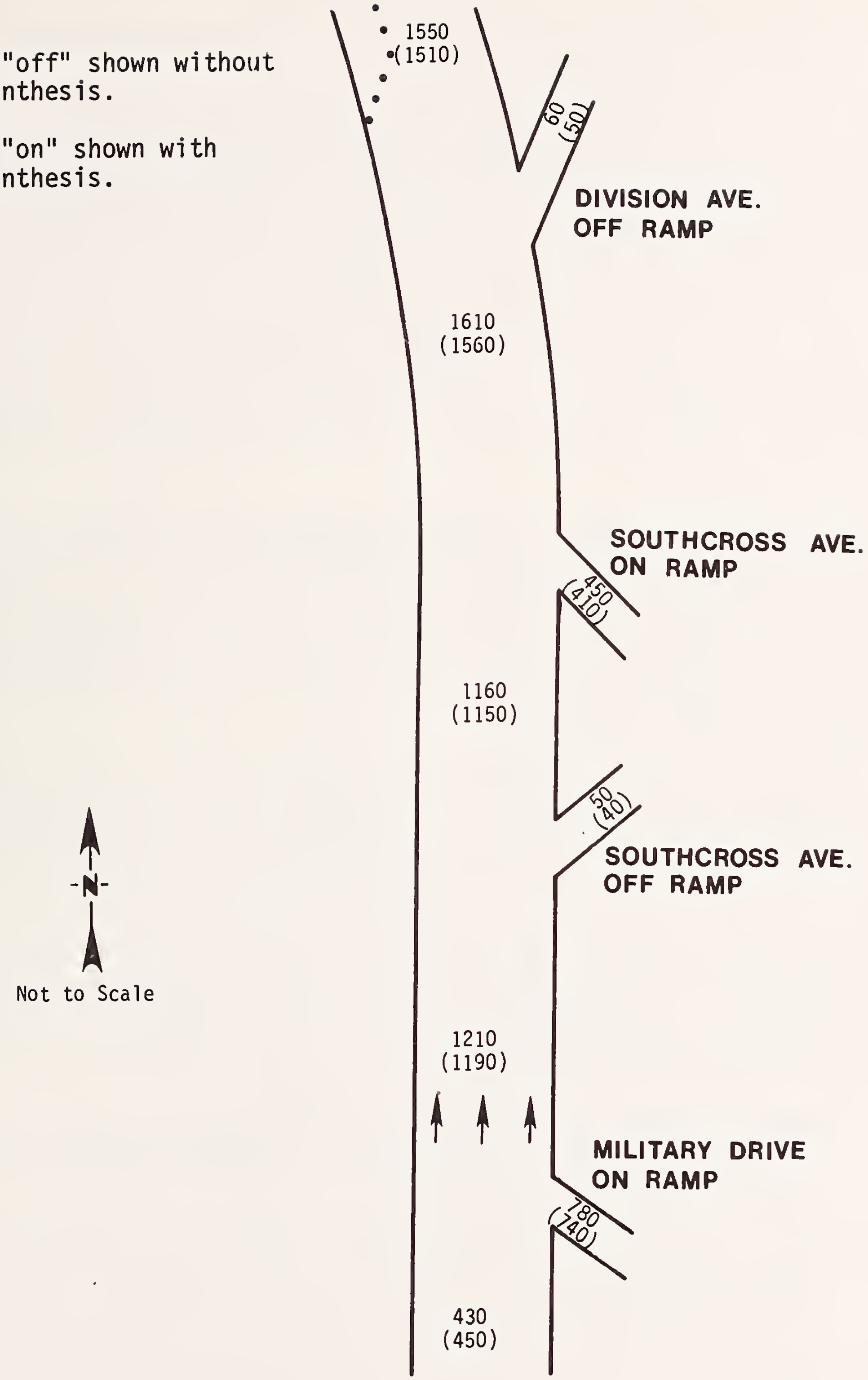


Figure 21 - Hourly Volumes During Study

fewer drivers would enter the closed median lane) when messages are displayed than when the CMSs are blank.

Figure 22 illustrates the percent of median lane traffic remaining in the closed lane at various distances upstream from the cone taper. The data are expressed in terms of the percent change in the median volumes at each count station in comparison to that originally in the lane at Station 1 located upstream from the CMS. Negative percentages indicate less traffic in the lane in comparison to Station 1; positive percentages reflect increased volumes in the lane resulting from more drivers moving into than out of the median lane.

The results reveal that the CMS did indeed encourage drivers to vacate or avoid the closed median lane. Although the percent volumes in the closed median lane at the various count stations were not low while the CMS message was displayed, they were significantly lower than periods when the CMS was blank.

The curves in Figure 22 illustrating the percent change in volumes show that during normal periods (without a CMS message) there was a large increase in median lane volumes as traffic progressed from Station 1 to Station 8. Volumes at Station 7 were 60% higher than at Station 1. Volumes at Station 8, located 700 ft. (213 m) upstream from the beginning of the cone taper, were 29% higher. (The drop in volumes between Stations 7 and 8 are attributed to the LEFT LANE CLOSED AHEAD sign and the driver's perception of the flashing arrowboard and lane closure).

In contrast, while the CMS message was displayed, volumes at Station 7 were 4% lower than at Station 1. Volumes at Station 8 were 17% lower. When the 17% reduction at Station 8 was compared to the 30% increase that resulted with the CMS blank, the net effect was a 47% greater reduction in the lane volumes with the CMS than what occurred when the sign was blank.

As previously stated, the volumes in the median lane at Station 8 [located 700 ft. (213 m) upstream from the beginning of the cone taper] were only 17% lower than at Station 1. There were site specific factors that influenced the lane distribution of traffic in the study area, and consequently effected on the results. These were:

1. the relatively high proportion of traffic (compared to the freeway) on the Military on-ramp located a relatively short distance upstream from the CMS,

2. the presence of an additional relatively high volume on-ramp at Southcross Ave. located downstream from the CMS, but upstream from the cone taper.

3. the existence of a right-side lane drop downstream from the worksite, and

4. the relatively short decision sight distance to the lane closure.

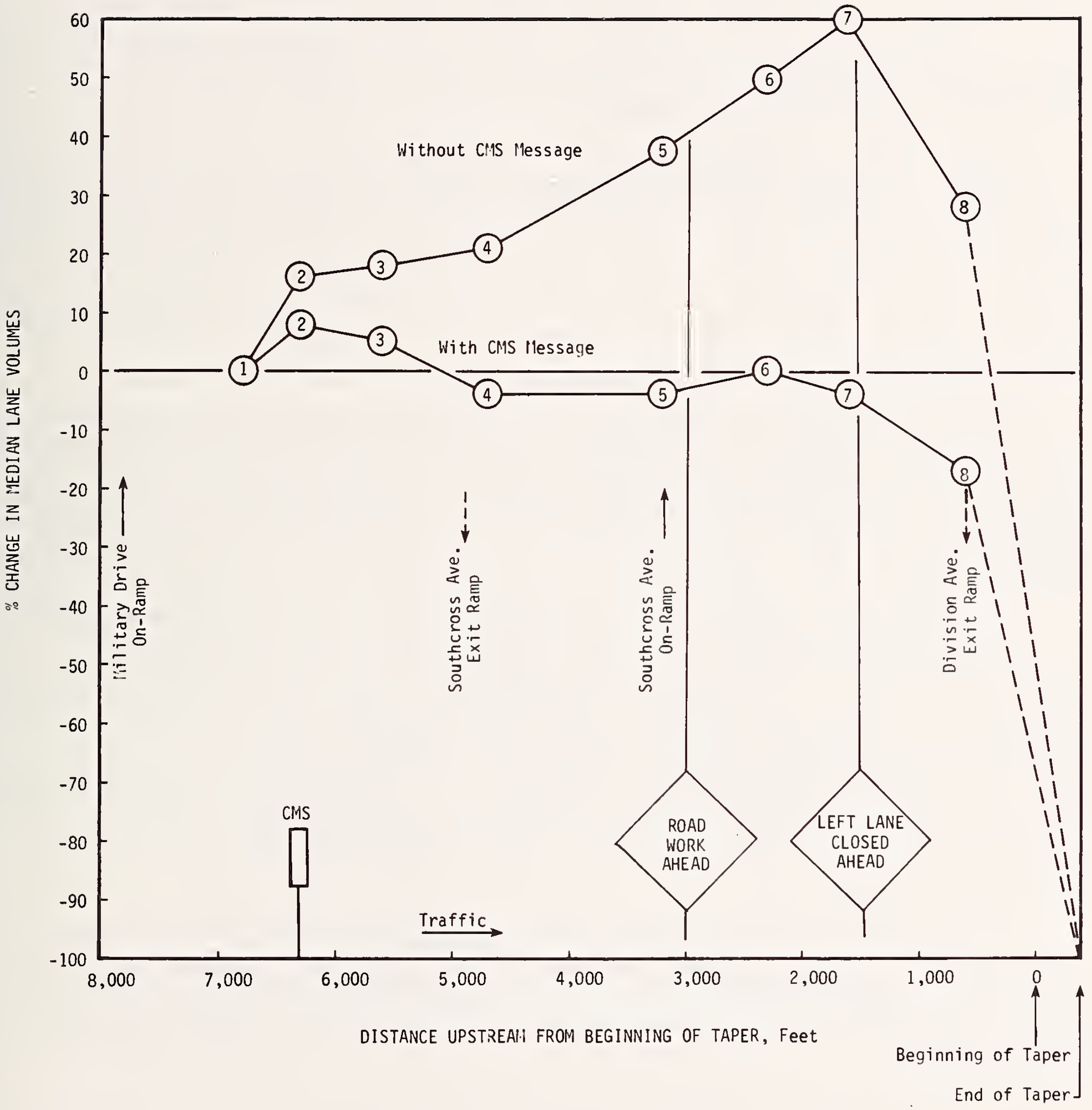


Figure 22 - Volume Changes in the Median Lane Closed for Maintenance

The freeway volumes in advance of the Military Drive on-ramp, located only 1500 ft. (467 m) upstream from the CMS, averaged about 460 vph during the study. The volumes on the Military Drive on-ramp averaged 740 vph. Thus, the ramp volumes were much higher than the upstream freeway demand. Observations in the field revealed that a large percentage of the on-ramp drivers moved into the center and median lanes almost immediately after entering the freeway. The high rate of lane changing resulted in a relatively high driver task load, and it is probably safe to assume that many drivers did not have an opportunity to read the CMS message.

Another factor that affected the lane distribution of traffic was the Southcross Avenue on-ramp. The ramp was downstream from the CMS and approximately 2600 ft. (792 m) upstream from the cone taper. Volumes on the ramp during the study averaged 410 vph. Although this can be considered as being light traffic, it was high relative to the freeway volumes near the ramp. The freeway volumes downstream from the ramp averaged 1660 vph; 26% came from the on-ramp. Thus, at least 26% of the freeway drivers during the study did not see the CMS when it was activated.

The third influential factor was the right-side lane drop downstream from the work zone. Drivers familiar with the "loss" of the shoulder lane most likely travel in the left two lanes to avoid the possibility of becoming "trapped" in the discontinuous lane. Thus, it is speculated that the right side lane drop influenced several drivers to travel in the center or median lanes.

The fourth influencing factor was the relatively short decision sight distance to the lane closure. Research (11) indicates that although the majority of drivers vacate the closed lane after reading the appropriate static work zone signs, a relatively high percentage (approximately 20%) will not leave the lane until they actually see evidence of the closure (e.g., cones or maintenance vehicles in the lane, arrowboards, etc.). Research (11, 12) also indicate that drivers must perceive a freeway lane closure at least 900 ft. (274 m) upstream from the cone taper. Shorter sight distances do not provide adequate time for most freeway drivers in the closed lane to take appropriate actions.

Observations during the San Antonio studies indicated that the sight distance to the lane closure was less than 900 ft. (274 m). Although an arrowboard with a sequencing arrow was used in the traffic control setup, the horizontal curvature of the freeway adversely affected the driver's perception of the lane closure.

Chapter 11

DIVERSION STUDY

Site Description

As previously stated, on March 17th and 18th, 1980, guardrail repairs on old I-35 near the stockyards north of the I-35/I-10E interchange necessitated the closure of the inside lane of the two-lane section. The work was performed between the hours of 9:00pm and 3:00am. A schematic of the study area is shown in Figure 19. The traffic management strategy using the CMSs was designed to encourage thru drivers to avoid the work area by diverting to the new I-35 route.

Study Approach

An analysis of traffic volumes furnished by the SDHPT San Antonio District prior to the study indicated that northbound volumes approaching the I-35/I-10E interchange would be approximtely 1500 vph from 9-10pm and 1000 vph from 10-11pm. Volumes would then drop sharply below 500 vph. Because of the expected low volumes after 11pm, the decision was made to end the field study at 11pm. It was reasoned that driver credibility would be affected if diversion messages were displayed when the volumes were low. Also, a few vehicles could affect the percentage distributions on the primary and diversion routes, and interpretation of results therefore would be difficult.

The messages designed for the study are shown below:

Diversion Message	Warning Message
ROADWORK AT STOCKYARDS	CAUTION
THRU TRAFFIC USE I-10E/I-37	ROADWORK AT STOCKYARDS

In contrast to the lane-change study, the locations of the CMSs relative to the diversion point would allow use of both signs. Messages were designed with this intention. However, the plans were changed during the study when problems developed with the CMS closest to the diversion point. As a result, only the southernmost sign was used during the study.

The original plans also called for a diversion message and a warning message to be displayed for one full hour each. The latter message type was

incorporated into the study upon the request of the SDHPT maintenance supervisor in charge of the roadwork. Messages were to be counterbalanced by changing the sequence of the messages during the second night of the study. Again, CMS problems on both study days required changes in the field. The final message display times are as follows:

	Diversion Message	Warning Message
March 17, 1980	9:40-10:20 pm	10:20-11:00 pm
March 18, 1980	9:00-10:00 pm	10:00-11:00 pm

License plates of vehicles passing a network of recording stations were recorded continually throughout each study period to determine travel patterns of thru drivers. The recording stations were selected to permit, as closely as possible, accurate determination of travel patterns on both the primary and diversion routes. Preliminary investigations prior to the studies indicated that there could be certain problems with reading license plates of vehicles at night. In particular, it was determined that reading license plates of vehicles traveling on freeway-to-freeway ramp connectors would be more difficult than for vehicles on the freeway. Thus, redundant recording stations were set up on ramp connectors along the diversion route. In addition, a station was added at the I-35/I-10W ramp because previous studies revealed a high percentage of drivers traveling north on I-35 near the CMSs interchange with I-10W. License plate and volume recording stations are shown in Figure 23.

Results

Nighttime license plate O-D studies presented greater challenges than the daytime studies. There was concern about the accuracy of reading license plates at night. Therefore, after the data were transcribed from the magnetic tapes, an analysis was conducted to compare the license data to manual volume counts made during the study.

The results revealed that nighttime O-D license plate studies can be effectively conducted in freeway corridors with accuracies within acceptable levels at most sites. There may be selected sites (e.g., freeway-to-freeway ramps) where it is difficult to find a safe location at the sites which would still enable them to read the license plates. Accuracies may be low at these sites. The results also indicate, as expected, that accuracy will increase with training and by assigning additional personnel at freeway and connector ramp recording stations than what would normally be required during daylight hours.

Tables 9 and 10 show comparisons of the recorded license plates to the manual counts for the two study days. On Monday, the percent of license plates read at the recording stations ranged from 70% to 88% and averaged 79%; on Tuesday it ranged from 80% to 95% and averaged 88%. Because of the extreme difficulty in reading license plates at the Station C--the I-37/I-35 connector ramp--during the Monday study, it was excluded from the Tuesday study.

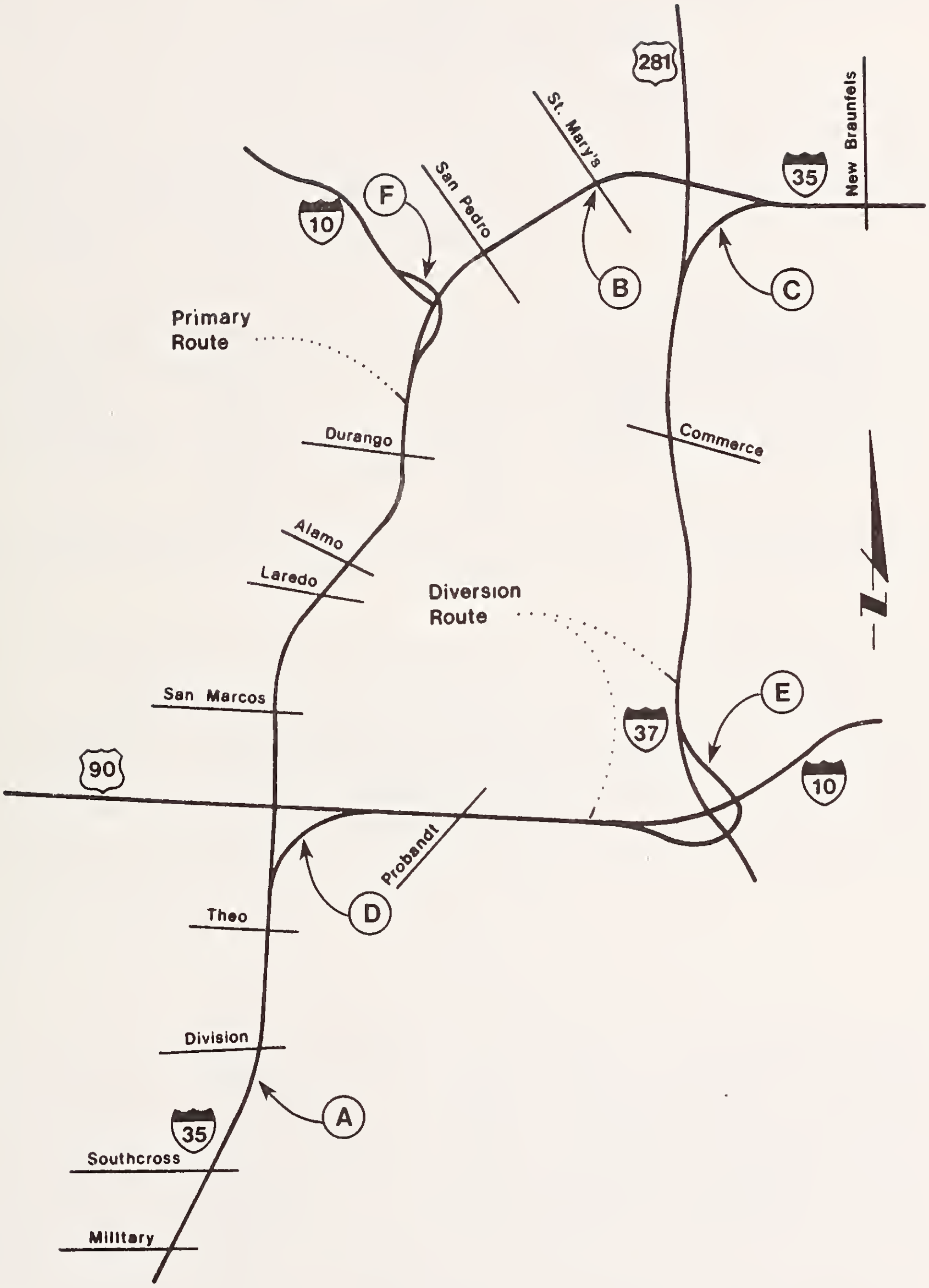


Figure 23 - License Plate O-D Study Locations
(March 17-18, 1980)

TABLE 9

COMPARISON OF RECORDED LICENSE PLATES
AND MANUAL COUNTS
Monday, 3/17/80 — 9:40 pm - 11:00 pm

	Total Volumes From Manual Counts	Recorded License Plates	
		Number	Percent
I-35 at Division (Station A)	992	868	88
I-35 at St. Marys (Station B)	1004	702	70
I-35/I-10E Ramp (Station D)	387	282	73
I-10/I-37N Ramp (Station E)	307	233	76
I-35/I-10W Ramp (Station F)	776	650	84
TOTAL	3466	2735	79

TABLE 10

COMPARISON OF RECORDED LICENSE PLATES
AND MANUAL COUNTS
Tuesday, 3/18/80 -- 9:00 pm - 11:00 pm

	Total Volumes From Manual Counts	Recorded License Plates	
		Number	Percent
I-35 at Division (Station A)	1678	1506	90
I-35 at St. Marys (Station B)	1752	1409	80
I-35/I-10E Ramp (Station D)	608	576	95
I-10/I-37N Ramp (Station E)	480	429	89
I-35/I-10W Ramp (Station F)	1538	1435	93
TOTAL	6056	5355	88

Personnel originally at this site were reassigned to other stations. Although data from Station C were not reduced, it was estimated that only about 30% of the license plates were read. Monday's recording experience, coupled with the reassignment of field personnel (particularly placing more people at the connector ramps), was reflected during Tuesday's studies.

Further studies were made to evaluate the accuracy of the computer match-up program using the data collected during this study. Discussions of the approach and results are presented in Appendix H. In summary, the analysis revealed that the computer routine matched 34% fewer vehicles than actual. Thus, the data presented in this section of the report were adjusted to reflect the disparity of missed matches.

Table 11 summarizes the percentage of total northbound I-35 traffic using the primary and diversion routes during the study. Two important findings are evident from the combined data for Monday and Tuesday: First of all, thru traffic comprised only 11% of the total traffic measured on I-35. Secondly, there was an increase in the percentage of drivers using the diversion route while the diversion message was displayed.

A more sensitive MOE is the percent thru drivers using the two routes when the messages were displayed. A summary of such a comparison is presented in Table 12.

It is interesting to note from Table 12 that the distribution of traffic on the primary and diversion routes was quite similar on both days. More important is the significant increase in the percent of thru traffic using the diversion route while the diversion message was displayed. The combined Monday and Tuesday data show that 15% more thru drivers used the diversion route when the diversion message was displayed in comparison to the times when the warning message was activated--47% during the warning message and 62% during the diversion message.

Discussion

Any conclusions reached from this study must be accompanied with qualifiers because of surrounding influencing factors. The results compare the effects of a diversion message to a warning message. It is possible that many drivers familiar with the geometric conditions on I-35 near the stockyards speculated that congestion existed in the area due to the lane closure. Thus, advance warning of the lane closure may have encouraged some drivers to voluntarily use the diversion route. If this assumption is correct, then the warning message may have masked the greater effects of the diversion message. Compared to no message at all, the diversion message may have shown a higher use of the diversion route. In retrospect, the ideal study approach would have been to compare the effects of both the warning and diversion messages to a blank sign.

Conversely, the time effects of the messages during long-term maintenance (several nights) were not studied. Once the drivers who regularly divert

TABLE 11

PERCENTAGE OF NORTHBOUND I-35 TRAFFIC
USING PRIMARY AND DIVERSION ROUTES

Message Type	Total Northbound I-35 Traffic at Division Ave.	Percent Using Primary Route	Percent Using Diversion Route
Monday, 3/17/80			
Warning	556	7	7
Diversion	436	4	7
Tuesday, 3/18/80			
Warning	985	5	5
Diversion	693	4	7
Monday & Tuesday, Combined			
Warning	1541	6	5
Diversion	1129	4	7
TOTAL	2670	5	6

TABLE 12

PERCENTAGE OF THRU TRAFFIC
USING PRIMARY AND DIVERSION ROUTES

Message Type	Total Northbound I-35 Traffic at Division Ave.	Percent Using Primary Route	Percent Using Diversion Route
Monday, 3/17/80			
Warning	73	51	49
Diversion	46	37	63
Tuesday, 3/18/80			
Warning	98	54	46
Diversion	73	38	62
Monday & Tuesday, Combined			
Warning	171	53	47
Diversion	119	38	62
TOTAL	290	47	53

become aware of the absence of congestion, they may elect to remain on the primary route. Credibility may be an issue. On the other hand, it may be that drivers would divert just to stay away from the work zone section at night regardless of whether there is congestion. These statements are speculative; additional studies are necessary to resolve these issues.

PART V

CHANGEABLE MESSAGE SIGN

SYSTEM

DESIGN AND OPERATIONS

Chapter 12

CMS HARDWARE AND OPERATION DESCRIPTION, PROBLEMS AND RECOMMENDATIONS

Introduction

The San Antonio point diversion CMS hardware and operations were briefly discussed in previous sections of this report. With the danger of being repetitive, they will be reviewed in greater detail in this chapter. Attention will be focussed, however, on the authors' assessment of the positive features of the system and some of the problems encountered. Recommendations will be provided based on the experiences in San Antonio.

Hardware and Operational Description

Two trailer-mounted computerized bulb matrix CMSs (Figure 24) were used to present diversion information to northbound I-35 drivers in San Antonio. The signs, available from previous TTI research studies, provided versatility in message length, display format and rate of display.

Messages were presented on a 4 ft. 10 in. (174.3 cm) high and 15 ft. 4 in. (467 cm) wide display board. Each of the two lines was composed of an array of 33-watt incandescent light bulbs, 7 rows by 64 columns, which formed a letter height of 18 in. (46 cm) with a maximum of 13 characters capability. The bulbs were protected from sun glare by a glare-screen attached to the front panel of the display. Previous research by TTI (2) has shown 650 ft. (198 cm) to be the 85th percentile legibility distance for these signs.

The ability of displaying a message on a sign was provided to the operator through the use of a digital computer located on the front side of the trailer in an environmental cabinet (Figure 24). Messages to and from the computer were transmitted and received through a teletypewriter (TTY) (see Figure 25). The TTY allowed for remote control of both signs through the use of an acoustical coupler located on the side of the TTY. The sign operator dialed the number of a telephone located in the CMS computer cabinet, placed his telephone ear/mouthpiece in the coupler, and then controlled the sign with the TTY. He would then repeat the process for the second sign. Automatic dial-up cards were used to reduce the time required to operate the signs.

Freeway surveillance was accomplished by police freeway patrols supplemented during the peak periods with police helicopter patrols (Figure 26) when weather permitted. Incident information and requests for sign messages were radioed to a single police dispatcher who not only dispatched police vehicles to accident scenes throughout San Antonio, but also controlled the CMSs. No additional funds were available to the SAPD for their participation in the CMS demonstration project. They operated the system within existing police funding and manpower constraints.

Figure 24 - Lamp Matrix Changeable Message Sign

Figure 25 - Teletypewriter with Acoustical Coupler

Figure 26 - Accident Scene from San Antonio Police Department Helicopter

Field officers and dispatchers were trained by TTI and police supervisors about two weeks prior to the June 1, 1978 starting date of operations. Following the training session, a CMS operation review package was prepared by TTI and distributed to the field officers and dispatchers. The review package, presented in Appendix G, discussed the purpose of the system and provided guidelines for message selection. It also contained a list of the messages and message numbers. The guidelines were in the form of matrices identifying the specific message number that should be displayed based on the location of the accident and the location of the back of the queue. Message numbers, and consequently the messages, changed when the back of the queue moved either upstream or downstream. Four matrices were developed: two for blockage of one lane during peak and off-peak periods, and two for total freeway blockage during peak and off-peak periods.

Also included in the review package was a step-by-step dispatcher's procedure for operating the CMSs. Note that the procedure lists 26 steps that were required to display a message on both signs, and 26 steps to turn the signs off.

The planned scenario of operations was as follows: when a freeway patrol officer would notice unusual congestion, he would drive to the scene of the incident. (Helicopter pilot would fly to view the scene.) The patrol officer would either have some idea as to location of the back of the queue or would obtain this information from another patrol officer or the helicopter pilot. He would then look at the appropriate matrix and request that the dispatcher display the message which coincides with the message number.

Using the message chart (Appendix G), the dispatcher would then identify the specific computer message number for each sign. He would dial Sign 1 and display the appropriate message; then dial Sign 2 and display the message.

It is important to note that due to the software design and storage limitations of the CMS computers and the desire by TTI to use 120 messages, the message numbers shown on the 4 matrices and the computer storage numbers for the messages are different (see Appendix G). For example, if an accident occurred at Alamo blocking one lane during the am peak period and the queue extended to I-10E, the figures in Appendix G show that Message 32 should be displayed. The dispatcher would then look on the Dispatcher's Guide to find that in order to display Message 32, he must send a command to Sign 1 to display Message D-15, and to Sign 2 to display Message D-6.

As the queue increased or dissipated, other patrol officers on their way to assist the officer now at the scene would notify the dispatcher of a new message number if required.

Problems and Recommendations

Operator's Control Console

The remote control console used in San Antonio was a TTY. Although TTI researchers had no problems with the TTY while operating three trailer-mounted CMSs in Dallas (4), some of the police dispatchers seemed to be apprehensive about the equipment. The problem was compounded by the need to punch a "D" on the keyboard followed by a number. Some of the dispatchers lacked the confidence that the number they punched would display the desired message, even though they had a message number chart available.

There were also many occasions of dispatcher apprehension about whether the message requested was actually displayed. Although the message "D-number" was printed by the TTY printer when a message was displayed, the message content was not. This added to the operational uncertainties.

The amount of operator action to display a sign message after a sign was "contacted" was excessive. As many as seven buttons on the keyboard had to be depressed merely to display one message and to have the D-number and computer clock time printed.

The number of CMSs that can be efficiently controlled with a TTY is also important to consider. TTI personnel had no problems in operating three CMSs in the Dallas system. However, it is doubtful whether one technically trained individual could effectively and efficiently operate more than three signs in an urban area using a TTY as a control console even though he could devote his full attention to sign control. Traffic conditions change too rapidly.

Recommendations--A TTY remote control console can probably be effectively used in an urban area CMS system to control up to three CMSs by a technically oriented individual provided he can devote full attention to operating the signs needed to be activated. A push-button console should be used when the system is operated by local or state police or non-technical personnel, or the system has more than three CMSs. The push buttons should contain the specific CMS message that will be displayed when the buttons are depressed.

Positive visual message verification should be provided. A message display board should be available when either the signs are operated by non-technical personnel or when there is a large number of signs to control. The message display board must allow the operator to quickly identify the exact message content and the freeway locations where messages are displayed. Simultaneous display of the information is desirable. Technically oriented operators could get by with a CRT display provided the number of signs is small.

Operator Considerations

Reports (2, 3) have cited factors such as operator boredom as critical in the effective operation of CMS systems. Although incidents are random and there may be long intervals when the signs are not needed, the preparedness

and alertness of the operator must not significantly diminish. Operator overload, rather than boredom, was a problem in San Antonio.

The CMS system operator in San Antonio time-shared responsibility with dispatching police and other emergency vehicles to locations throughout the City. Needless to say, during the peak periods when the need for the CMSs was the greatest, the dispatcher was very busy responding to incidents. Overload in these critical situations required that the operator prioritize his tasks. Operation of the CMSs was of lower priority.

One major problem that arose in San Antonio was that because of the infrequent use of the signs by specific dispatchers due to shift rotations (signs are most frequently needed during peak periods) and other factors, the operators' self-confidence in the ability to operate the signs dwindled over time. This, in part, was a contributing factor to the decline in the use of the signs during the second year of operation. No provisions were made in the research project to retrain the operators.

Recommendations--The operator should be able to devote full attention to CMS operation during the peak traffic periods when incidents are most likely to occur. During off-peak periods other related tasks are advisable, but the operator must be in a position to devote full attention to the signs when an incident occurs.

The operator should have a strong working knowledge of the freeway and streets in the corridor influenced by the CMSs. This knowledge will permit him to more efficiently and effectively select the appropriate information options for display.

The operator must be well-trained and confident about his ability to operate the system. Recognizing that sign usage in the smaller metropolitan areas or in rural areas may be infrequent, provisions should be made to retrain the operators and to practice sign operation under simulated conditions. The CMS control console and associated hardware and software should be designed to allow the operators to go through the actual motions of operating the system and seeing the messages appear on the confirmation panel without the messages actually being displayed on the signs in the field. These simulations should be conducted with a supervisor at least every 6 months. The operator should be encouraged to practice the simulated operations on his own at more frequent intervals.

System Operation

The decision was made by the local highway and police agencies that the San Antonio CMS system would be operated by the SAPD. The SAPD administrators and supervisors were enthusiastic supporters and lent considerable encouragement for this arrangement. Many institutional, personnel and funding constraints limited the capability of the local police to staff the system to the levels needed to maintain an effective system during the two year study. However, the SAPD believes that the police should have operational responsibility.

Recommendations--Some local police departments are in a position to assume responsibility for operating MIDSs in urban areas. When the system is to be operated by local or state highway agencies, the police should be involved with the planning and design of the system, and must be an involved partner when the system is operated.

Telecommunications

As previously discussed, the operator's console (TTY) in San Antonio communicated with each sign by way of a telephone dial-up system. This required that a sign had to be called before a message could be displayed, changed or removed. Although the amount of time required would not be excessive and the efficiency of operation would not be seriously affected for a two-sign system with an experienced operator, problems could arise with larger urban area systems or when operators are not proficient in the use of the CMS system. Experiences with the telephone dial-up system in San Antonio indicated that it was quite inadequate for the occasional user who had a multitude of other simultaneous responsibilities.

Recommendations--It appears that the telephone dial-up system may be adequate for a small number of isolated CMSs in urban areas or for small CMS systems in rural areas. However, most urban systems should employ other telecommunications techniques to minimize the time required to change messages on the signs.

Surveillance

Surveillance is required for incident detection and an assessment of the operating conditions in the corridor. Detection of incidents, especially during peak periods, posed very little problem in this study. The thoroughness with which the SAPD covered the freeway system with ground and air units reduced incident detection time to the lowest time possible without extensive freeway instrumentation. For maximum effectiveness, incidents should be detected rapidly enough to allow the initiation of diversion before the exits to alternate route(s) are blocked by the queue from the incident.

Accurate identification of the incident location is also critical. Selection of messages is highly dependent on the location of the incident. The more specific the description of the incident in the CMS messages, the more critical the identification of the incident location becomes. For example, "ACCIDENT AT DURANGO" requires a much more accurate location determination than does "ACCIDENT NORTH OF US-90."

A second important function of surveillance is to provide information about conditions in the corridor. In San Antonio, the dispatcher/sign operator had to rely on those officers in the field to describe the conditions on the freeway. The patrol officers were in most cases so busy with investigating the incident and moving traffic, that they were not able to provide this information to the operator. Thus, the operator was required to "blindly" operate the CMS without having the assurance and confidence that the messages

he displayed were the correct ones for the existing conditions. Eventually, some of the operators decided not to use the signs.

Recommendations--Use of police patrols is a good way to identify the occurrence and location of freeway incidents in small metropolitan areas. It is not adequate to provide detailed information concerning the traffic conditions on the freeway so that the operator can make appropriate decisions about the messages. Electronic detector surveillance complemented with closed circuit television are necessary parts of a CMS system in urban areas.

PART VI

DATA ACQUISITION

Chapter 13

DATA ACQUISITION FOR POINT DIVERSION

Introduction

To evaluate the effectiveness of the MIDS in San Antonio, three types of data were collected: sign usage data, accident data, and volume data. This section of the report relates how the data were collected, problems encountered, and recommendations for future systems.

Sign Usage Data

The CMSs were operated by SAPD dispatchers thru use of a teletype phone control system. The teletype printout created by use of the CMSs was the initial source of data.

Operators were asked to record the following information on the printout each time the CMSs were used: time, date, accident assignment number, location of accident, time message activated, and time message cleared. Message codes were printed automatically when the message was activated or cleared. TTI personnel retrieved these printouts on a weekly basis.

Field personnel were asked to complete a supplemental form (in addition to their accident report) to be routed to the Accident Prevention Bureau for each time they requested usage of the CMSs. This form included the following information: date, time, accident assignment number, reason for message (accident, stall, maintenance or other specified), incident location, location traffic was backed up to, the number(s) of the message(s) displayed, and any additional information/comments.

Taped conversations between SAPD patrol officers and the CMSs operators were rerecorded onto cassette tape by TTI personnel for selected sign usage cases. The tapes were made primarily for determining any operational problems encountered by the CMS operators or field personnel in using the CMSs but also provided additional information about the incident for which the signs were used.

Additional information about the operation of the CMSs were obtained during meetings conducted among participating agencies and in informal interviews with various SAPD staff members including dispatchers, field personnel, and administrators.

Numerous conditions arose that directly resulted in incomplete or loss of data. The dispatcher's primary duties were to monitor and respond to any traffic situation within the entire city limits of San Antonio (dispatch patrolmen, wreckers, ambulances, etc.). The time to operate the CMSs during peak periods and adverse weather was limited. As a result of these conditions, coupled with infrequent use, the dispatcher often failed to record

elements of the pertinent data onto the teletype printout. In addition, field officers frequently failed to complete or submit the supplemental form with their Accident Report. The incomplete data caused some of the potential case study incidents to be omitted from the studies, and contributed to delays in retrieving data for other cases.

Recommendations--The relevant sign usage data should be recorded by the CMS operator and not the field officer. One method would be to provide the operator with a check list and forms which outline variables for the pertinent data. Since forms have a way of not getting completed a better approach would be to program the CMS signs in such a manner as to automatically print on hard copy certain of these variables and list the others for the operator to record data by responding to a key word. Information such as the time of day, message content, and sign number should be programmed to print automatically each time a message is displayed or cleared. Key words for other data as required in the research herein are: accident assignment number, date, location, accident or other, and traffic backed to. This not only provides the operator with confirmation of what is actually being displayed but a record for future use.

Accident Data

SDHPT maintains accident report files on all accidents which occur on State maintained roadways. In searching these files, TTI personnel compiled a listing of pertinent information on a monthly basis for all northbound accidents which occurred within the study area and time. This information included: day of month, police patrol district, time accident occurred, time police arrived, location of accident (nearest cross-street or intersection), and accident assignment number. The information from these listings were used to select non-signed incidents with similar characteristics and non-incident periods (for base conditions) to compare to cases for which CMSs were used. In addition to these listings, TTI personnel also obtained copies of the Accident Reports for those accidents for which CMSs were used. Information extracted from these reports were: severity, number of vehicles involved, lane(s) where the accident occurred, weather conditions, surface conditions, light conditions, location of accident in terms of distance (in feet) and direction from nearest cross-street, officer's interpretation of how accident occurred, contributing factors, and a sketch (combination collision and condition diagram). These data were summarized for each sign usage case to provide the staff a complete picture of each situation.

A time lag of one to six weeks existed between the time of the accident and when the SAPD furnished SDHPT with copies of the Accident Reports. SDHPT filed all copies by location. However, accidents involving fatalities or damage to State property were filed separately. Initially, TTI was not informed that these latter two files were maintained. This caused some confusion and delay, but otherwise these data were easily retrieved.

Recommendations--Accident Reports of sign usage cases should be attached to the CMS operator's report. Any other pertinent information or comments should also be included in a report completed by the operator.

Volume Data

In order to estimate the number of vehicles diverting during a lane closure incident, six temporary automated traffic counters were installed at key locations. These locations were: one on the freeway mainlanes upstream from the diversion point, three on freeway-to-freeway connector ramps, and two on exit ramps to the downtown area. Volume data from these counters, supplemented by volume data from four mainlane permanent traffic counters, were to provide the researchers with the complete traffic flow picture.

Under a separate contract with FHWA for the first year of the research and under a subcontract with TTI the second year, the SDHPT agreed to:

1. Install and maintain the six temporary automatic traffic counters, collect 5-minute counts continuously and furnish TTI with all data tapes;

2. Maintain the four permanent automatic traffic counters, and furnish TTI with copies of standard monthly printouts (1-hour intervals from three and 15 minute intervals from the fourth).

Data tapes obtained from the six temporary counters were transmitted to TTI approximately every two weeks. TTI converted the data from these tapes onto magnetic tape for easier handling. These data were then listed and checked for completeness and quality. Data for selected days were edited, formatted, and printed in a matrix.

To expedite the initiation of these volume counts, TTI purchased the six electro-mechanical temporary automatic traffic counters. SDHPT purchasing would have added significant delays. These counters were not of the same brand as those possessed by the SDHPT. Thus, initial malfunctions took longer than normal to correct.

The counters were designed to operate continuously for short duration counts (i.e., one- or two-day periods). Count data are punched on paper tape with normal sensing accomplished by pneumatic tubes. In order to obtain 5-minute counts, time clocks were put into the temporary counter. Twelve volt wet cell batteries were used to power these counters because the cost of batteries versus the cost of installing line power was substantially greater.

Initially, these counts were made continuously but two problems arose:

1. the paper tape punched by the counter(s) exceeded the take-up spool capacity in less than one week, and

2. the batteries discharged in less than one week.

The solution was to operate the counters from 7am to 7pm daily. Since the counters were designed to run continuously, the turning off at 7pm and on at 7am caused some erroneous counts. This problem was resolved after talking to the manufacturer and bench-testing a few counters.

Other problems which contributed or caused loss of volume data were:

1. normal discharging of batteries--after a period of time, batteries lost their ability to hold a charge,

2. periodic malfunction of paper tape mechanism,

3. electrical problems occurred after counters had been in use for a period of time,

4. counters damaged or destroyed when struck by vehicles, and

5. time lag between counts being completed and data tapes being processed caused delays in notification of counter problems.

Recommendations--If counts are to be made continuously, permanent counters should be used. Likewise, line power should be run to each permanent counter. Manual counts from various locations should be made to determine proper placement of counters in order to obtain the desired level of sensitive. To assure quality, the agency maintaining counters should also process the data.

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REFERENCES

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APPENDICES

APPENDIX A

GUIDE SIGN MODIFICATIONS FOR I-35 REROUTING

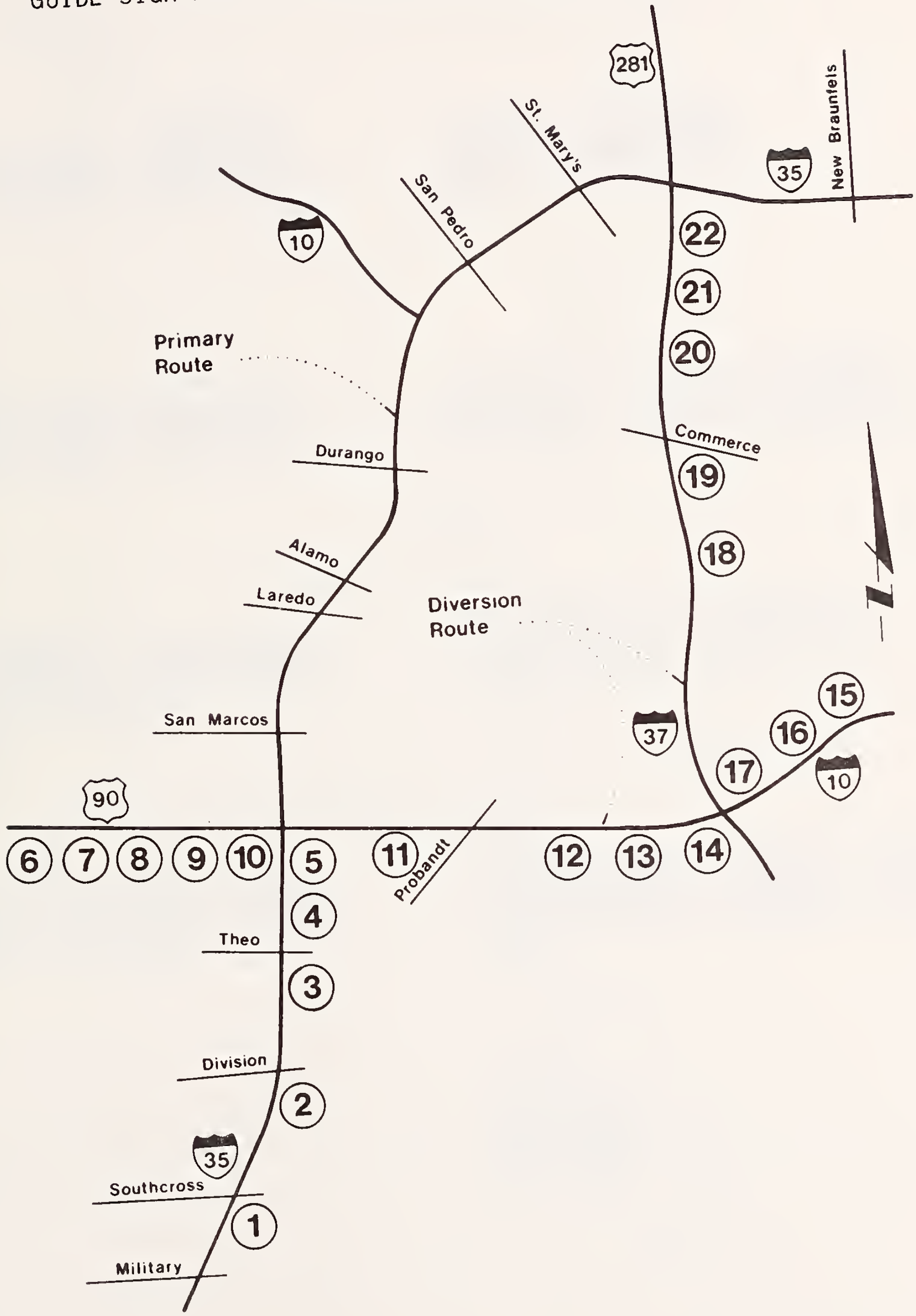


Figure 27 - Locations of Sign Changes for Northbound I-35 (Austin) Traffic

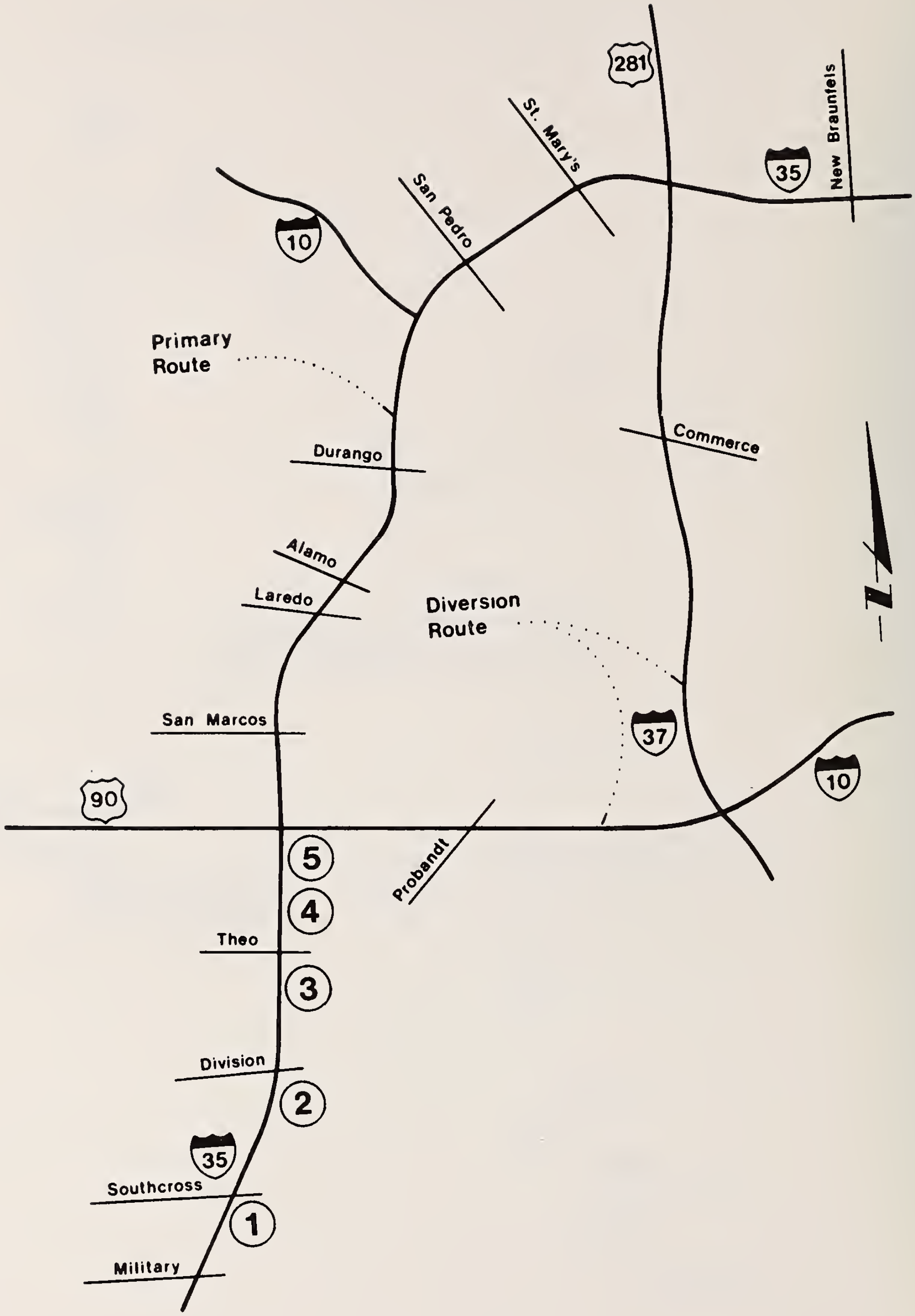


Figure 28 - Locations of Guide Signs on Northbound I-35
Approaching Diversion Route

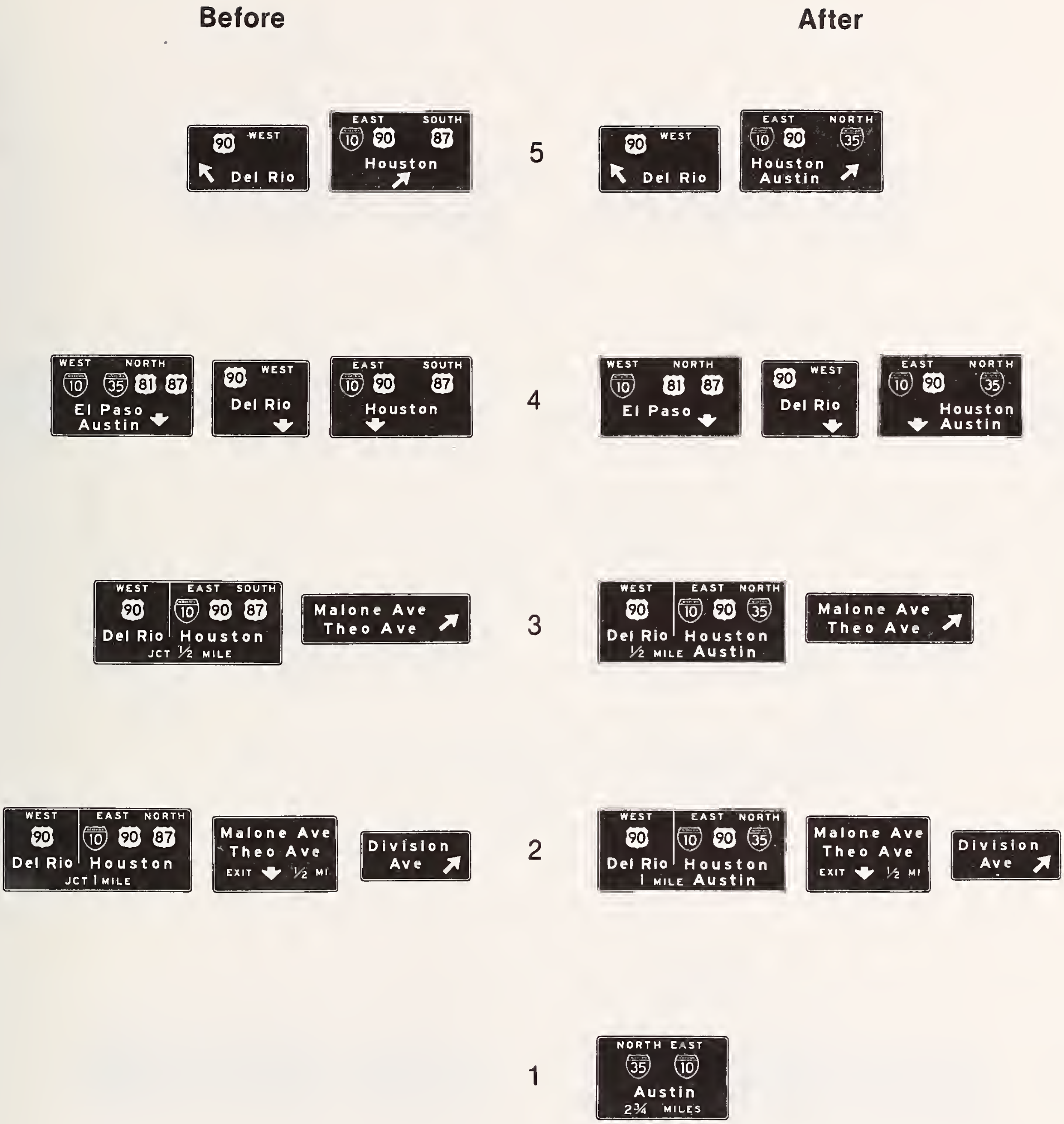


Figure 29—Guide sign modifications on northbound I-35
approaching diversion route

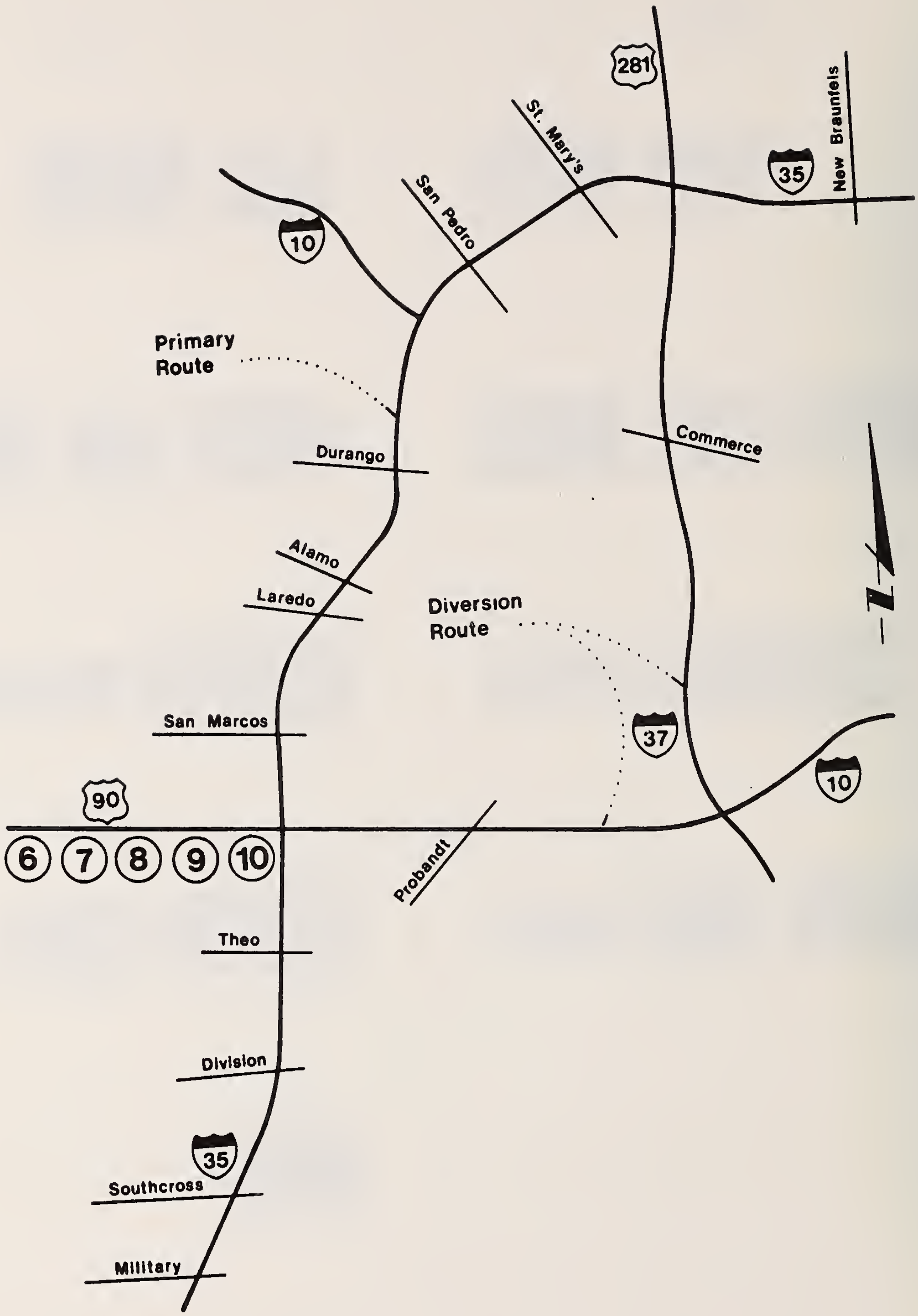


Figure 30 - Locations of Guide Signs on Eastbound US-90 Approaching Diversion Route

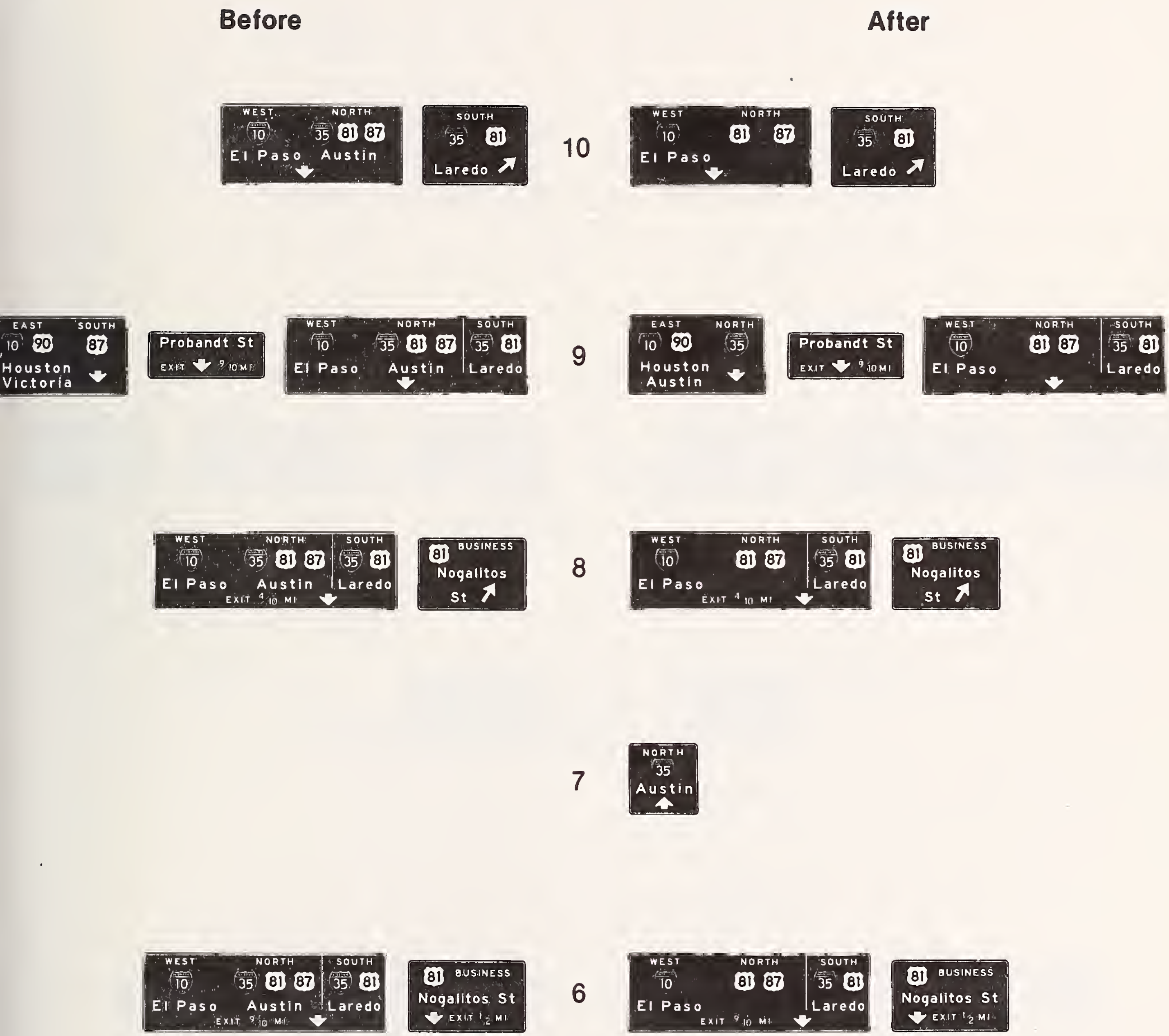


Figure 31—Guide sign modification on eastbound US-90 approaching diversion route

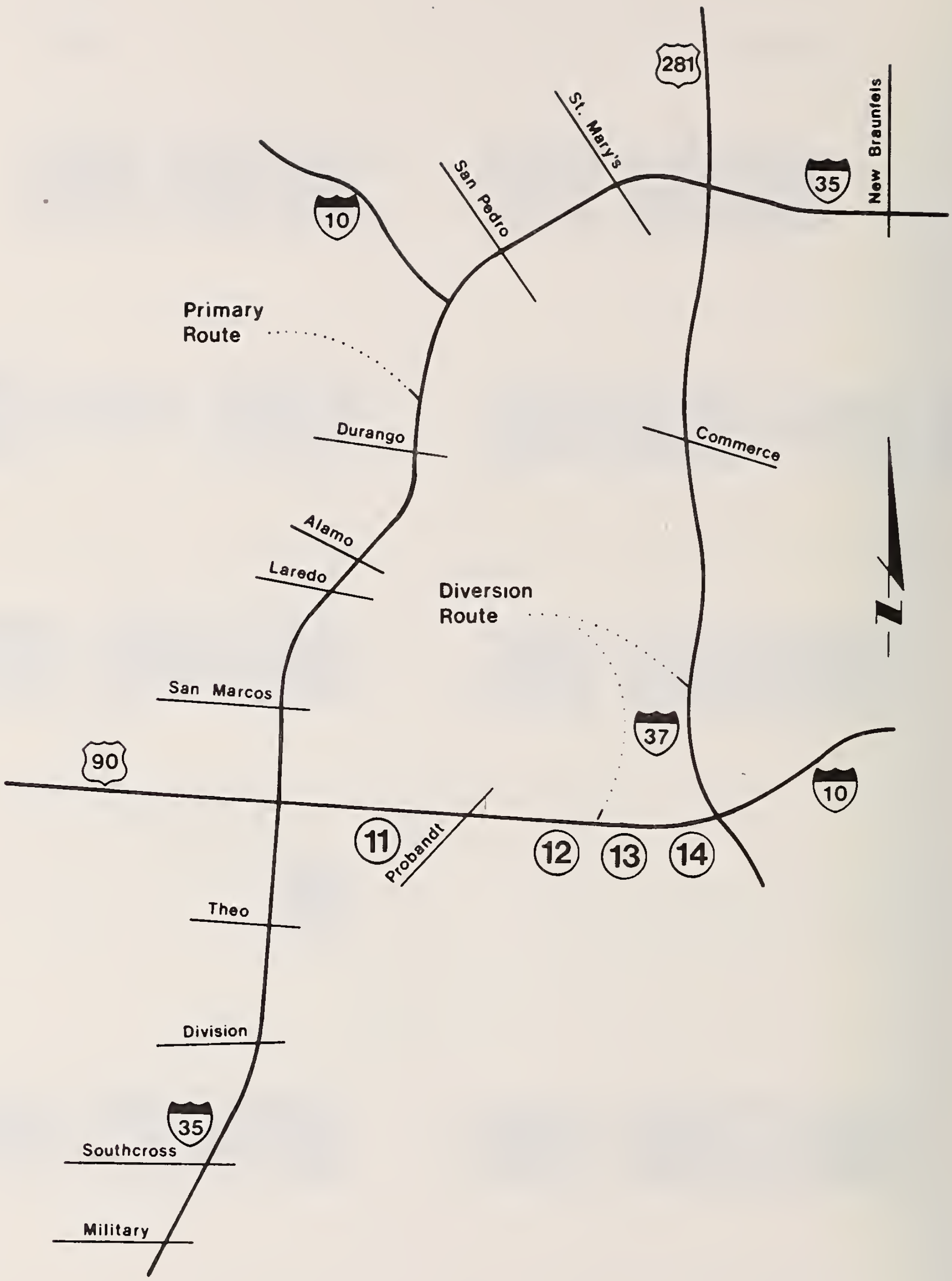


Figure 32 - Locations of Guide Signs on Eastbound I-10
Along Diversion Route

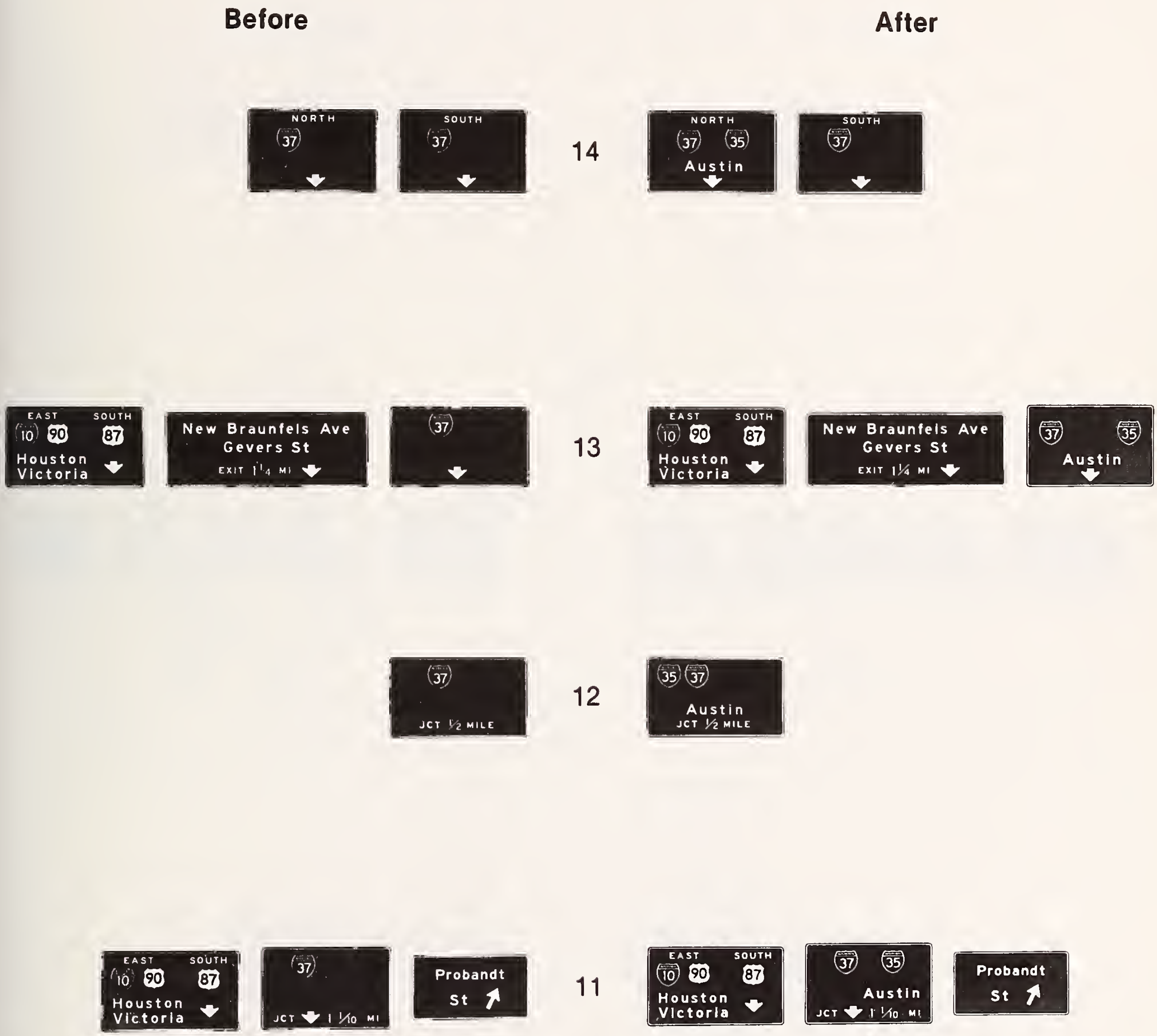


Figure 33—Guide sign modifications on eastbound I-10 along diversion route

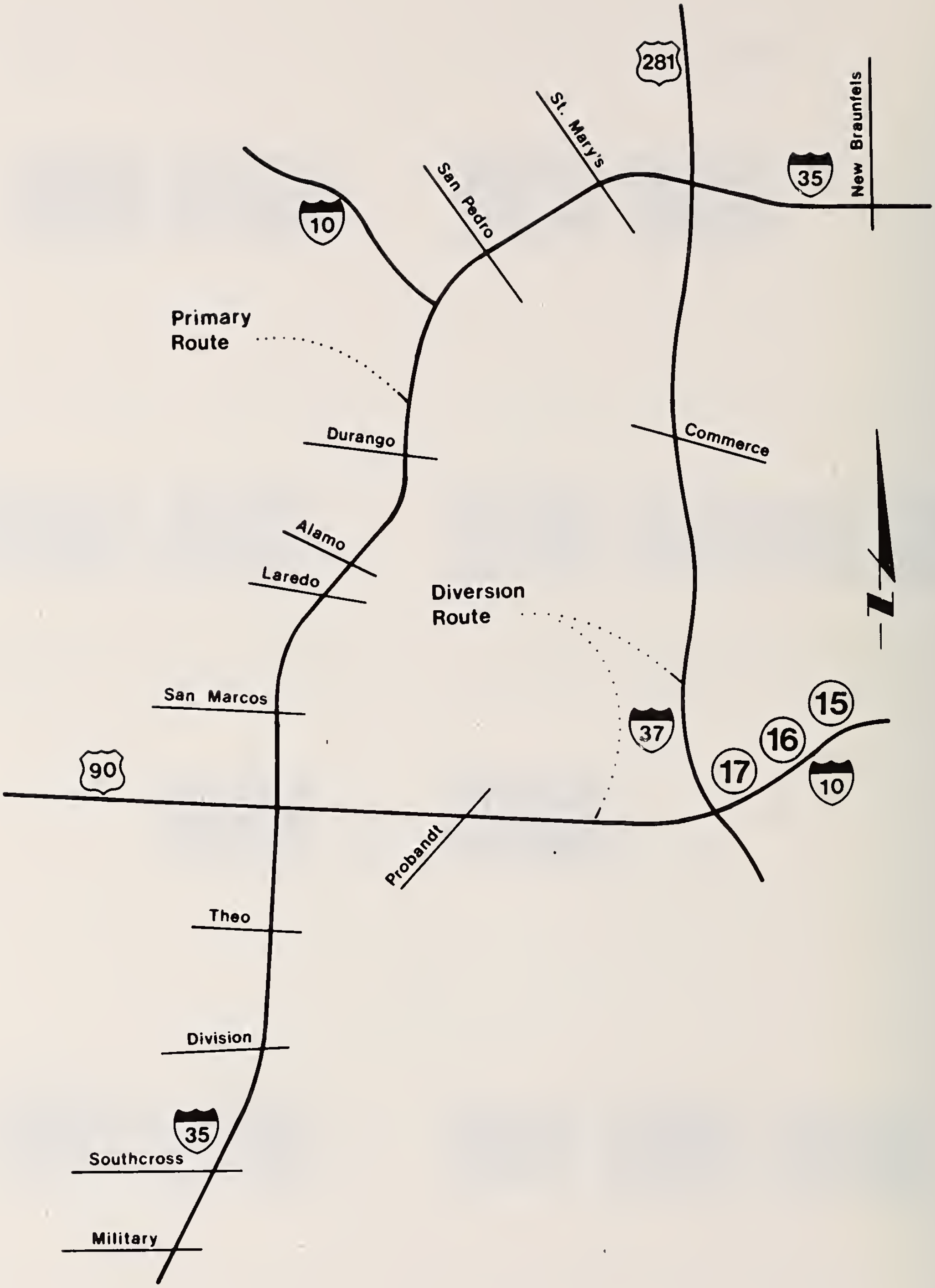


Figure 34 - Locations of Guide Signs on Westbound I-10
Approaching Diversion Route

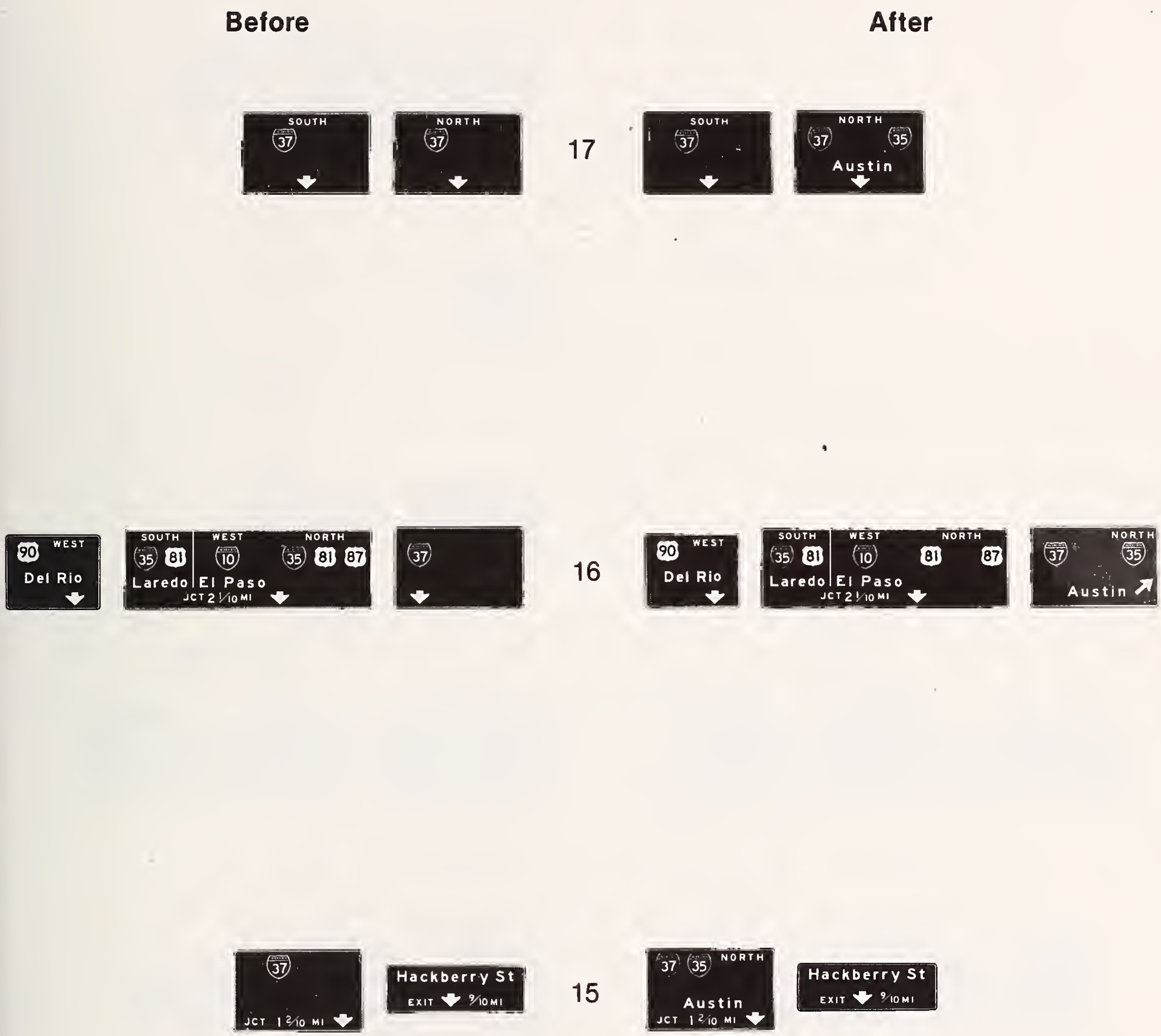


Figure 35—Guide sign modifications on westbound I-10 approaching diversion route

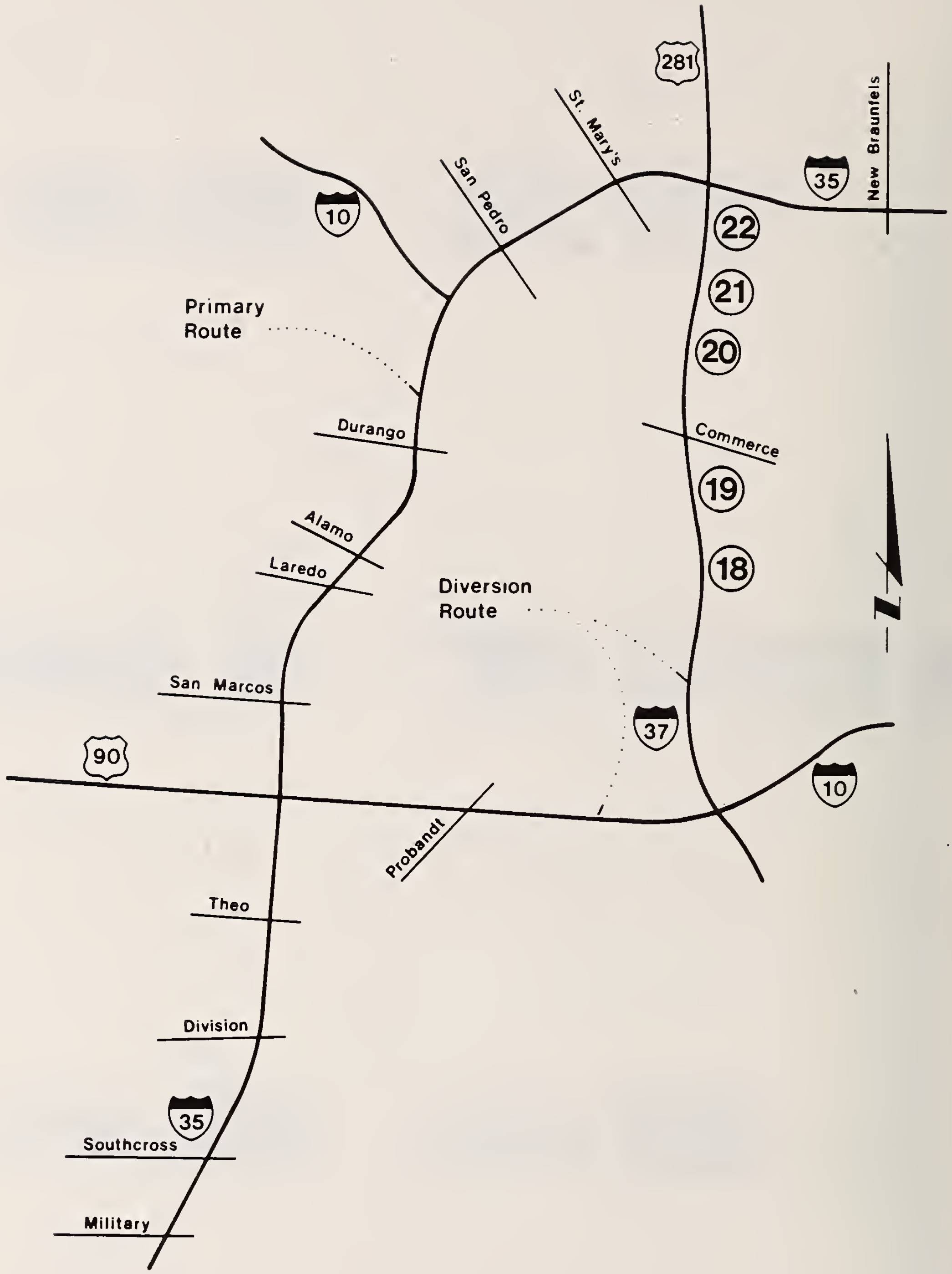


Figure 36 - Locations of Guide Signs on Northbound I-37 Along Diversion Route

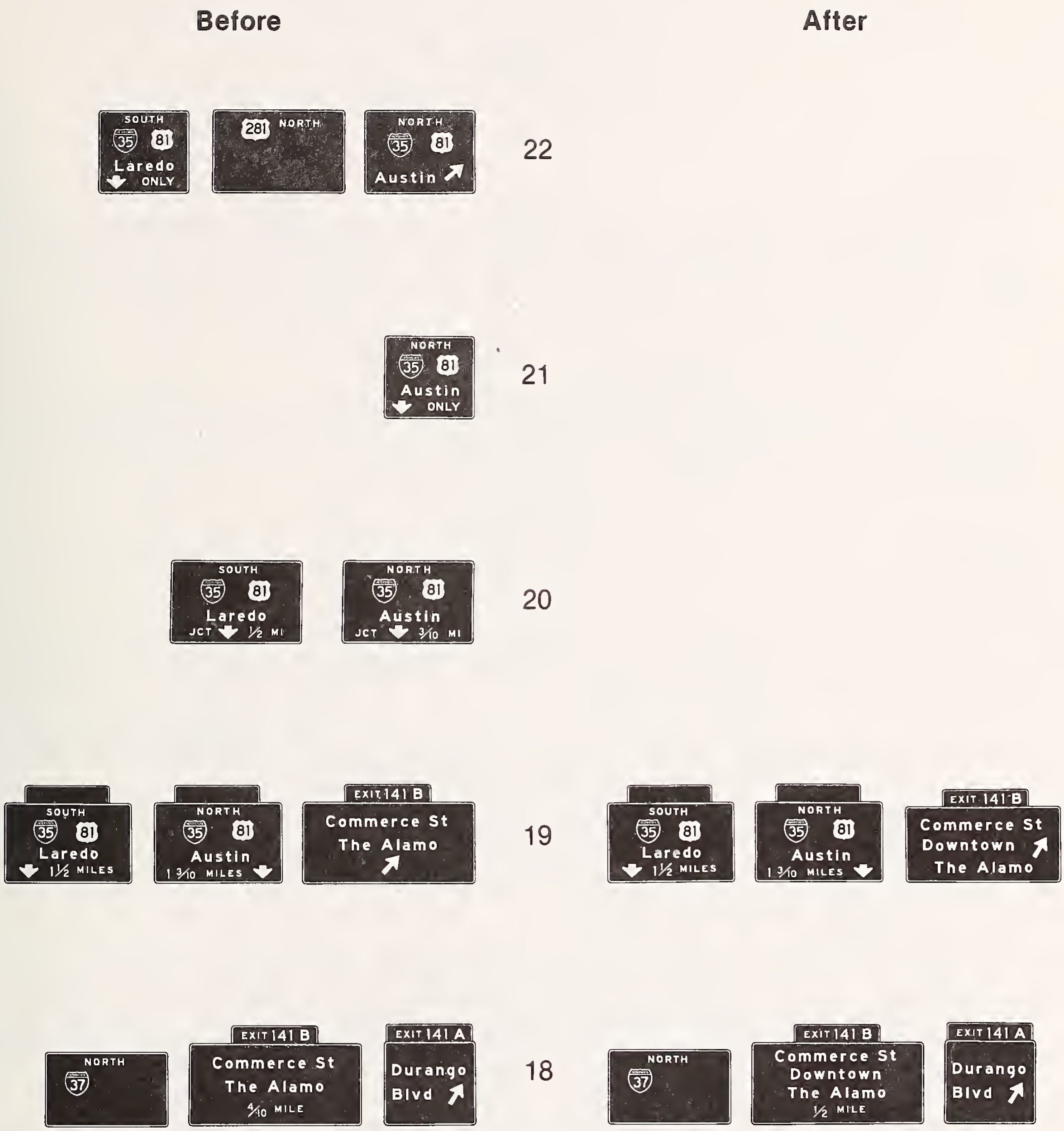


Figure 37—Guide sign modifications on northbound I-37 along diversion route

APPENDIX B

EVALUATION OF DIVERSION DUE TO RE-ROUTING OF I-35

Objectives

The primary objective of this phase of the study was to determine how many thru drivers on northbound I-35 shifted to the diversion route as a result of the guide sign changes. Specifically, the objectives were to:

1. estimate the number of potential diverters, and
2. estimate the amount of diversion.

A thru trip is one with an origin south of the diversion point (I-35/I-10E interchange) and destination north of the diversion link (I-37/I-35 interchange).

Approach

Before Studies

Estimation of the number of potential diverters involved the following steps:

1. Determination of the number of thru drivers from a previous planning survey's origin-destination (O-D) data;
2. Development of annual traffic volume growth factors in the corridor;
3. Extrapolation of the planning survey volumes to the study year (1977); and
4. Distribution of thru drivers by route (primary or diversion) from license plate O-D survey.

The most recent study providing information from which thru trips could be estimated was the "1969 Origin-Destination Survey" prepared by the San Antonio Bexar County Urban Transportation Study (SABCUTS)(1). This survey gives detailed information on the number of daily trips among various external stations (at the County line) and internal districts (within the County).

The two external stations and internal areas that are most relevant to the I-35 redesignation study are shown in Figure 38. These stations and areas were assumed to include virtually all O-D trip combinations that would require drivers to travel on primary and diversion routes.

A traffic volume growth factor (1969 to 1977) was developed based on traffic volumes collected over the years by a SDHPT permanent counter located

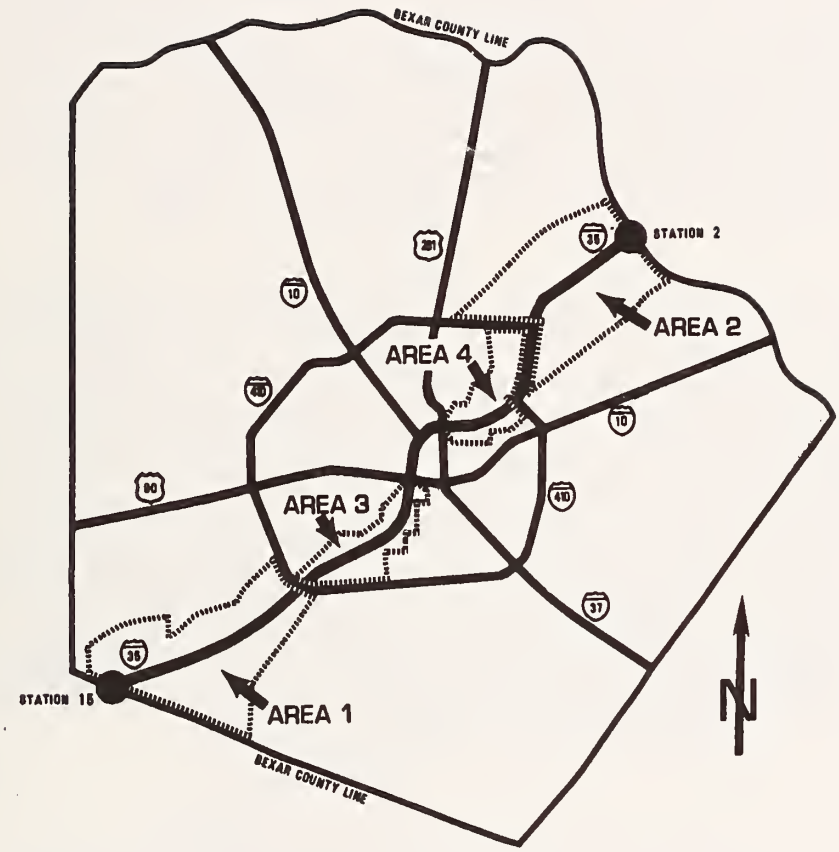


Figure 38 - Origin-Destination Stations and Areas Considered in Thru Trip Estimation

on the primary route near St. Mary's Street. The 1969 thru volumes from the planning survey O-D data were then extrapolated to 1977 conditions using the growth factor.

License plate O-D studies were conducted prior to the sign changes to estimate the distribution of thru drivers between the primary and diversion routes. Study days and time periods were selected to include a good sampling of non-local drivers since it was anticipated that this classification of drivers would best be influenced by the sign changes. The "before" O-D studies were therefore conducted on a Friday and Saturday (September 23 and 24, 1977) during the hours of 10-11:00am, 1-2:00pm, and 3-5:00pm. To conserve on study costs, license plate surveys were made only in the northbound direction. An assumption was made that the route redesignation would have similar effects on drivers traveling southbound as it did northbound.

The O-D study stations for the "before" surveys are shown in Figure 39. License plate numbers of all northbound vehicles were recorded at the "origin" location of the study area (Station A) and at the "destination" location on each of the two possible routes (Stations B and C). At Station C (the I-37 to I-35 connector ramp) personnel were able to read plate numbers from ground level and record them on cassette tape recorders. Stations A and B were high speed, high-volume freeway locations (I-35 at Theo Avenue and I-35 at Brooklyn Avenue). At these stations it was necessary for personnel to sit on overhead bridge structures and use binoculars to read and record the license plates. After the data were reduced from the tapes, the license plate numbers for vehicles passing the two "destination" stations (Stations B and C) were computer-matched against the plate numbers recorded at the "origin" (Station A) identify the total thru traffic on each route. This technique was previously used successfully by TTI in similar studies conducted in Dallas (2).

After Studies

Estimates of the amount of diversion was made from a license plate O-D survey conducted after the sign changes. The data were adjusted to reflect seasonal variations in traffic volumes.

License plate studies were conducted on a Friday and Saturday during the same time periods as the "before" studies. Because of the Christmas season, the studies were delayed until January 13 and 14, 1978 to reduce any possible bias due to the holiday traffic.

Results

1969 Thru Drivers

The results of the 1969 SABCUTS O-D data analysis are shown in Table 13. The analysis indicates that 4941 vehicles per day (total both directions) traveled thru the study area in 1969.

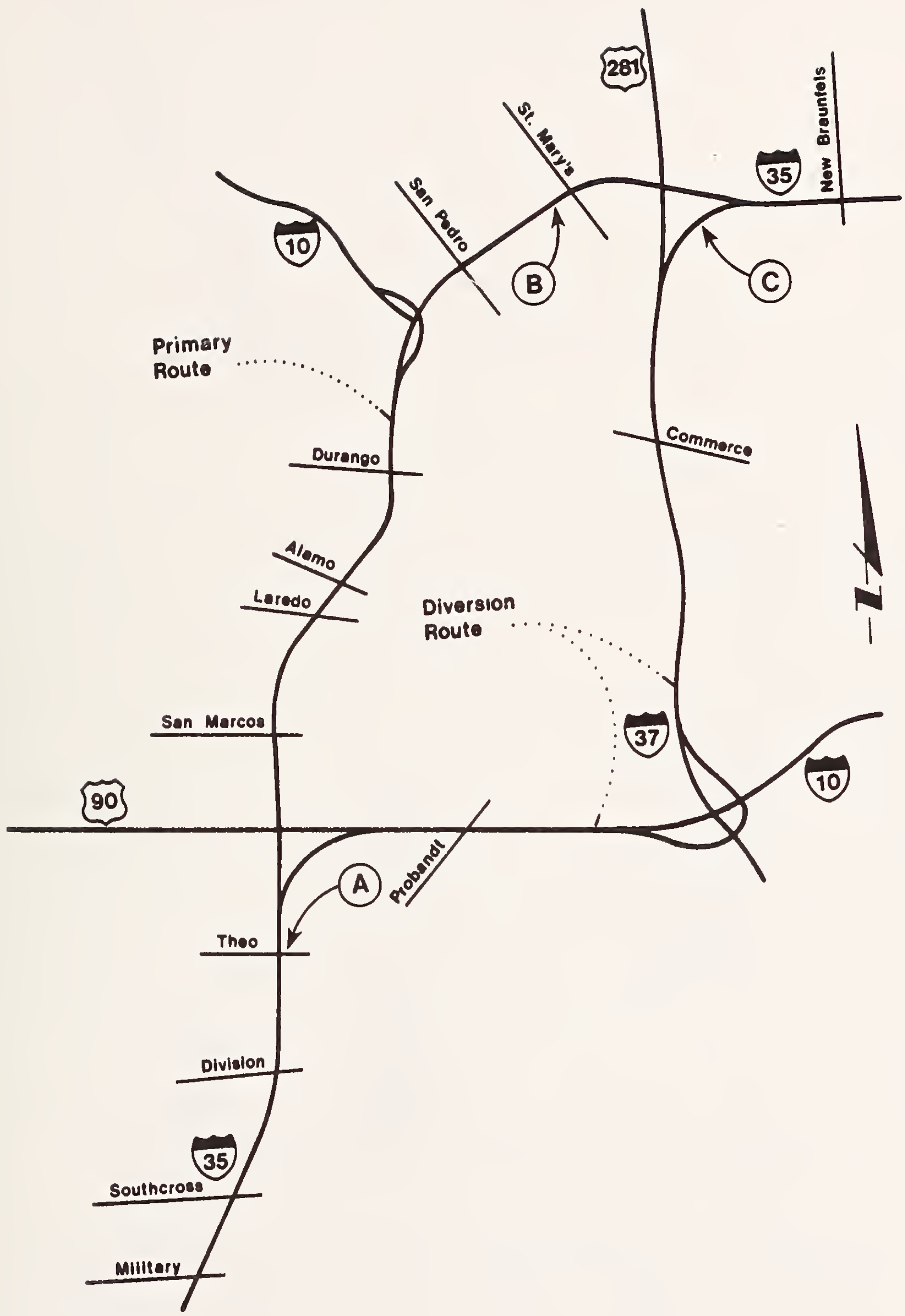


Figure 39 - License Plate Recording Stations

TABLE 13

THRU DAILY TRIPS AMONG EXTERNAL STATIONS AND INTERNAL DISTRICTS BASED ON 1969 O-D DATA

Bi-Directional Trips Between	and	TOTAL
(External-External)		
Station 2	Station 15	518
(External-Internal)		
Station 2	Area 1	13
Station 2	Area 3	213
Station 15	Area 2	61
Station 16	Area 4	133
(Internal-Internal)		
Area 1	Area 2	50
Area 1	Area 4	187
Area 2	Area 3	839
Area 3	Area 4	2927
	TOTAL	4941

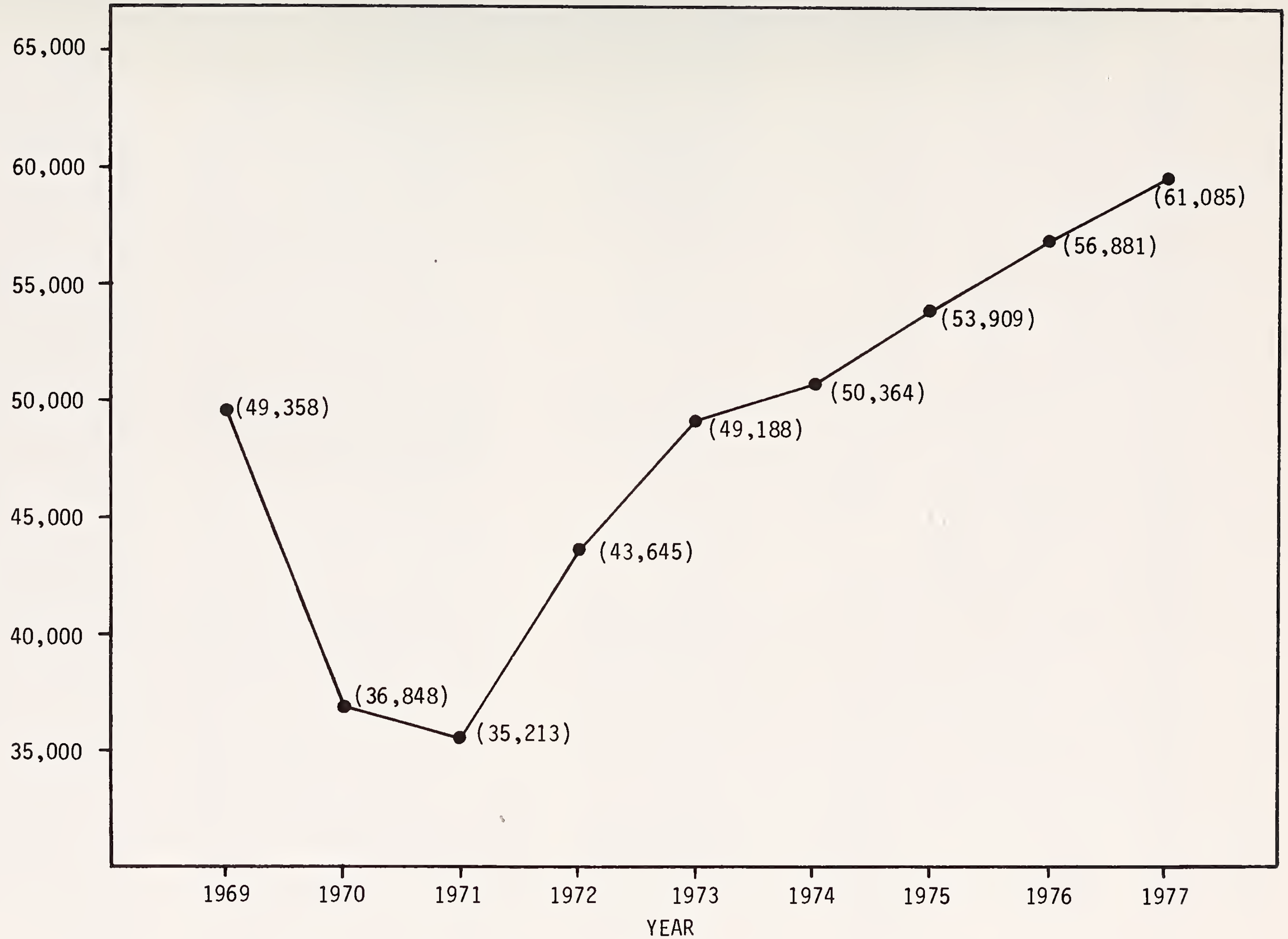


Figure 40 - Annual Average Daily Traffic on I-35 at St. Mary's Ave.

Traffic Volume Growth

The annual average daily traffic (AADT) in the Austin-Laredo corridor for the years 1969 through 1977 were estimated from counts taken on the primary route near St. Mary's Street. These data are shown plotted in Figure 40.

A marked decrease in AADT is noted in the period 1970-1972 when the I-35/I-37 interchange was under construction. A minor decrease in growth rate is also evident in 1974, probably due to the energy crisis.

The results show a change in AADT from 49,358 vehicles per day in 1969 to 61,085 in 1977--a 24% increase in volume.

Comparison of the 4941 thru trips estimated from the 1969 SABCUTS study and the 49,358 AADT from the counters revealed that the estimated thru trips on I-35 were 10% of the total traffic.

Estimated 1977 thru Volumes

If it is assumed that the percentage increase in thru trips was identical to the percentage increase in AADT, the 24% growth can be applied to the 1969 O-D data. This results in an estimate of 5960 vehicles per day (total both directions) traveling thru the study area in 1977. By further assuming an equal distribution of thru trips in both directions, 2980 thru vehicles per day are estimated in each direction.

License Plate Study

Although the license plate O-D study technique used in this project results in a larger sample size in comparison to other study approaches, license plate O-D surveys of freeway vehicles introduce two problems: First of all, not all license plates can be read. Secondly, computer routines are subject to matching errors. Thus, it was important to compare the actual volumes recorded by the survey party at the origin (input) station upstream from the diversion point to those obtained from automatic counters located near the survey station. Adjustments to the survey counts could be made should any discrepancies be noted in comparison to the automatic counters. In addition, reading and interpretation errors can result in 34% fewer vehicles being matched. (See Appendix K for discussion of computer matching errors.) The data must be adjusted accordingly.

A comparison of counts from the license plate study and automatic counters is made in Table 14. Assuming that the automatic counters yielded accurate data, the results show that the survey crew located at the freeway input station recorded on the average 88% of all vehicles passing the count station. Although this value represents a rather good sampling of the volumes, the license plate volume data must be adjusted upward by 12% to obtain a more accurate estimate of the number of thru drivers on each route. In addition, the volumes must be further adjusted by 34% to reflect errors attributed to computer matching.

TABLE 14

COMPARISON OF LICENSE PLATE SURVEY AND PERMANENT
COUNTER TOTAL VOLUMES
BEFORE SIGN CHANGES

Time Period	Total Northbound I-35 Traffic at Theo (Automatic Counters)	Northbound Traffic from O-D Survey: Number	Northbound Traffic from O-D Survey: Percent of Total Northbound Traffic
Friday, 9/23/77			
10:00-11:00 am	2210	1814	82
1:00- 2:00 pm	2530	2166	86
3:00- 4:00 pm	3020	2590	86
4:00- 5:00 pm	3130	2688	86
Friday Total	10890	9258	85
Saturday, 9/24/77			
10:00-11:00 am	2480	2224	90
1:00- 2:00 pm	2680	2416	90
3:00- 4:00 pm	2420	2164	89
4:00- 4:39 pm	2410	2249	93
Saturday Total	9990	9053	91
TOTAL	20880	18311	88

Table 15 presents a summary of the total thru volumes recorded during the license plate survey. The thru volumes were adjusted upward to reflect the discrepancies between the license plate survey and the automatic counter volumes and computer matching errors. The results reveal that on the average during the study period, the northbound thru traffic represented 10.2% of the total traffic entering the area upstream from the diversion point. This percentage compares favorably with the 10% thru traffic estimated in 1969, indicating that the percentage of thru trips remained rather constant over the years. Of primary importance is the distribution of thru drivers by route because these data indicate the diversion potential. Table 16 summarizes the results of the license plate survey reflecting the route choice by drivers. As can be seen in the Table, it is estimated that, on the average, 78% of all thru drivers used the primary route while 22% used the diversion prior to the sign changes.

Estimated Diversion Potential

It was noted earlier that an estimated 5960 thru trips were made each day in 1977 (2980 in each direction). Using the route distribution found in the license plate surveys, 78% or approximately 4650 thru trips per day were made on the primary route. This indicates the traffic available for diversion. This volume amounts to 8% of the total traffic on I-35.

Included in this diversion potential are all ranges of driver familiarity. Local drivers may elect to remain on the original I-35 route. Therefore, it should be recognized that not all of the drivers who could potentially use the diversion route would likely divert as a result of route redesignation.

Route Choice After Sign Changes

Table 17 compares the license plate O-D volumes with those of permanent counters. As can be seen, assuming the automatic counter data are accurate, the license plate freeway volume was on the average 89% of the total volume. This compares with 88% (Table 14) for the before study. As in the before study, the license plate data were adjusted upward to reflect the volume differences in comparison with the automatic counter and the 34% anticipated error due to the computer matching errors previously discussed.

Thru traffic as a percentage of total northbound traffic entering the study area is summarized in Table 18. After the route redesignation, the thru traffic represented 11.2% of the total northbound traffic; 8.1% used the primary route and 3.1% the diversion route. Thru traffic was 1.0% greater than before the sign changes. The increased thru traffic was essentially on the diversion route. Before the sign changes (Table 15), 8.0% of the total traffic used the primary route, and 2.2% used the diversion route. After the sign changes, 8.1% used the primary route and 3.1% used the diversion route.

Data summarized in Table 19 reveal that there was a 6% increase in the percentage of thru drivers who took the diversion route after the sign

TABLE 15

THRU TRAFFIC
BEFORE SIGN CHANGES

Time Period	Total Northbound I-35 Traffic at Theo	Thru Traffic		Thru Drivers Using Primary Route		Thru Drivers Using Diversion Route	
		Number*	Percent of Total	Number*	Percent of Total	Number*	Percent of Total
Friday, 9/23/77							
10:00-11:00am	2210	174	7.9	134	6.1	40	1.8
1:00- 2:00pm	2530	178	7.0	149	5.9	29	1.1
3:00- 4:00pm	3020	332	11.0	235	7.8	97	3.2
4:00- 5:00pm	3130	338	10.8	264	8.4	74	2.4
Friday Total	10890	1022	9.4	782	7.2	240	2.2
Saturday, 9/24/77							
10:00-11:00am	2480	263	10.6	217	8.8	46	1.8
1:00- 2:00pm	2680	304	11.3	232	8.7	72	2.6
3:00- 4:00pm	2420	225	9.3	161	6.7	64	2.6
4:00- 5:00pm	2410	316	13.1	272	11.3	44	1.8
Saturday Total	9990	1108	11.1	882	8.8	226	2.3
TOTAL	20880	2130	10.2	1664	8.0	466	2.2

*Adjusted

**Tape Recorder Malfunction

TABLE 16

PERCENT OF THRU DRIVERS BY ROUTE
BEFORE SIGN CHANGES

Time Period	Thru Drivers Using Primary Route		Thru Drivers Using Diversion Route	
	Number*	Percent of Thru Traffic	Number*	Percent of Thru Traffic
Friday, 9/23/77				
10:00-11:00 am	100	77	30	23
1:00- 2:00 pm	111	83	22	17
3:00- 4:00 pm	175	71	73	29
4:00- 5:00 pm	197	78	55	22
Friday Total	583	76	180	24
Saturday, 9/24/77				
10:00-11:00 am	162	83	34	17
1:00- 2:00 pm	173	76	54	24
3:00- 4:00 pm	120	71	48	29
4:00- 5:00 pm	203	86	44	14
Saturday Total	658	80	169	20
TOTAL	1241	78	349	22

*Adjusted

TABLE 17

COMPARISON OF LICENSE PLATE SURVEY AND PERMANENT
COUNTER TOTAL VOLUMES
AFTER SIGN CHANGES

Time Period	Total Northbound I-35 Traffic at Theo (Automatic Counters)	Northbound Traffic from O-D Survey: Number	Northbound Traffic from O-D Survey: Percent of Total Northbound Traffic
Friday, 1/13/78			
10:00-11:00 am	2100	1906	91
1:00- 2:00 pm	2510	2272	91
3:00- 4:00 pm	3070	2577	84
4:00- 5:00 pm	3050	2550	84
Friday Total	10730	9305	87
Saturday, 1/14/78			
10:00-11:00 am	2270	2117	93
1:00- 2:00 pm	2690	2562	95
3:00- 4:00 pm	2510	2332	93
4:00- 4:39 pm**	1684	1474	88
Saturday Total	9154	8484	93
TOTAL	19884	17789	89

**Tape Recorder Malfunction

TABLE 18

THRU TRAFFIC
AFTER SIGN CHANGES

Time Period	Total Northbound I-35 Traffic at Theo	Thru Traffic		Thru Drivers Using Primary Route		Thru Drivers Using Diversion Route	
		Number*	Percent of Total	Number*	Percent of Total	Number*	Percent of Total
Friday, 1/13/78							
10:00-11:00am	2100	198	9.4	138	6.6	60	2.8
1:00- 2:00pm	2510	284	11.3	228	9.1	56	2.2
3:00- 4:00pm	3070	356	11.6	278	8.9	83	2.7
4:00- 5:00pm	3050	303	9.9	197	6.5	106	3.4
Friday Total	10730	1141	10.6	836	7.8	305	2.8
Saturday, 1/14/78							
10:00-11:00am	2270	236	10.4	172	7.6	64	2.8
1:00- 2:00pm	2690	316	11.7	236	8.8	80	2.9
3:00- 4:00pm	2510	318	12.7	224	8.9	94	3.8
4:00- 4:39pm**	1684	208	12.4	138	8.2	70	4.2
Saturday Total	9154	1078	11.8	770	8.4	308	3.4
TOTAL	19884	2219	11.2	1606	8.1	613	3.1

*Adjusted

**Tape Recorder Malfunction

TABLE 19

PERCENT OF THRU DRIVERS BY ROUTE
AFTER SIGN CHANGES

Time Period	Thru Drivers Using Primary Route		Thru Drivers Using Diversion Route	
	Number*	Percent of Thru Traffic	Number*	Percent of Thru Traffic
Friday, 1/13/78				
10:00-11:00 am	103	70	45	30
1:00- 2:00 pm	170	80	42	20
3:00- 4:00 pm	204	77	62	23
4:00- 5:00 pm	147	65	79	35
Friday Total	624	73	228	27
Saturday, 1/14/78				
10:00-11:00 am	128	73	48	27
1:00- 2:00 pm	176	75	60	25
3:00- 4:00 pm	167	70	70	30
4:00- 4:39 pm**	103	66	52	34
Saturday Total	574	71	230	29
TOTAL	1198	72	458	28

*Adjusted

**Tape Recorder Malfunction

changes. Twenty-eight percent of the thru drivers used the diversion route in comparison with 22% who used it before the sign changes (Table 14).

The data were further analyzed to estimate the actual volume of traffic that was influenced by the sign changes during the study days in January. In order to estimate the volumes, two assumptions were made. First of all, it was assumed that the average percent of arriving freeway traffic on northbound I-35 determined from the license plate studies as traveling thru the study area is valid for the entire day. Secondly, the average percentage distribution of thru drivers on the two routes obtained from the field study was assumed to hold true for the entire day.

Another factor that had to be considered was the seasonal variation in traffic volume between September (when the before data were collected) and January. The volume data therefore must be normalized to account for the seasonal variations. Thus, the volume data were normalized in terms of annual average daily traffic. An estimate of the thru traffic using a specific route during one of the four study days was obtained from the following equation:

$$\begin{matrix}\text{Estimated Thru}\\ \text{Traffic on Route}\end{matrix} = \begin{pmatrix}\text{Total Traffic}\\ \text{on}\\ \text{I-35 at Theo}\end{pmatrix} \times \begin{pmatrix}\text{Seasonal Correction}\\ \text{Factor}\end{pmatrix} \times \begin{pmatrix}\text{Fraction of}\\ \text{Total Traffic}\\ \text{Using Route}\end{pmatrix}$$

Data used in estimating the average daily change in thru northbound traffic on each route are presented in Table 20. The total northbound volumes on I-35 were obtained from automatic counters located near Theo Ave. Seasonal correction factors were computed from data documented in the SDHPT annual summary of freeway volumes (3). The fractions of total traffic using each route were derived from the license plate O-D studies summarized in Tables 15 and 18.

Table 20 indicates that 1325 I-35 northbound thru vehicles per day used the diversion route during the September study days and 1000 vehicles per day during January--an increase of 325 vehicles per day (normalized to annual average daily traffic).

If it can be assumed that the change in the southbound direction is the same as the northbound, then it is estimated that approximately 650 thru vehicles per day on I-35 were influenced by the static sign change during the January study days.

In summary, the percentage of northbound drivers traveling thru the study area increased. In addition, there was a significant increase in the number of thru drivers that used the diversion route.

TABLE 20

ESTIMATED VOLUMES OF NORTHBOUND THRU TRAFFIC ON PRIMARY AND DIVERSION ROUTE DURING STUDY DAYS

Time Period	Total Northbound Traffic on I-35 at Theo (vpd)	Daily/ Seasonal Correction Factor	Primary Route: Fraction of Total Traffic Using Route	Primary Route: Estimated Thru Traffic (vpd)	Diversion Route: Fraction Total Traffic Using Route	Diversion Route: Estimated Thru Traffic (vpd)
Friday, 9/23/77	47,430	0.880	0.072	3000	0.022	900
Saturday, 9/24/77	45,510	1.036	0.088	4150	0.023	1100
			Average	3575		1000
Friday, 1/13/78	46,190	0.899	0.078	3200	0.028	1150
Saturday, 1/14/78	41.220	1.080	0.084	3750	0.034	1500
			Average	3475		1325

Average increase in thru northbound volumes on Diversion Route = 1325 - 1000 = 325 vpd

REFERENCES

1. San Antonio-Bexar County Urban Transportation Study. Origin-Destination Survey, 1969. Report No. 6B. City of San Antonio, Bexar County, Texas Highway Department, 1969.

2. G. D. Weaver, S. H. Richads, D. R. Hatcher, and C. L. Dudek. Human Factors Requirements for Real-Time Motorist Information Displays, Vol. 14 - Point Diversion for Special Events: Field Studies. Texas Transportation Institute. Report No. FHWA-RD-78-18. August 1978.

3. Texas State Department of Highways and Public Transportation. 1977 Annual Report--Permanent Automatic Traffic Recorders. Austin, Texas 1978.

APPENDIX C - QUESTIONNAIRES

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

COMMISSION

REAGAN HOUSTON, CHAIRMAN
DEWITT C. GREER
CHARLES E. SIMONS

ENGINEER-DIRECTOR
B. L. DEBERRY

IN REPLY REFER TO
FILE NO.

Dear Motorist:

The State Department of Highways and Public Transportation is continually searching for ways to improve your safety and convenience on our urban freeway system. Currently under evaluation are the primary freeway routes which carry northbound traffic through the City of San Antonio and the informational signs which guide traffic along these routes. On Friday, September 23, 1977, traffic studies were conducted on I-35, I-10, and I-37 in San Antonio to evaluate existing patterns of traffic movement through the city. We are asking a select group of motorists to help us further evaluate the results of these traffic studies.

Your vehicle was observed traveling northbound through San Antonio on I-35 between the hours of 10:00 am and 5:00 pm on September 23. We would appreciate your providing us with some additional information concerning your trip and others you have made through the city by completing the enclosed questionnaire. If you were not the driver of the vehicle, would you please ask the person who drove the vehicle to complete the questionnaire. Please return the questionnaire in the enclosed pre-paid envelope as soon as you can.

Thank you for your cooperation.

Very truly yours,

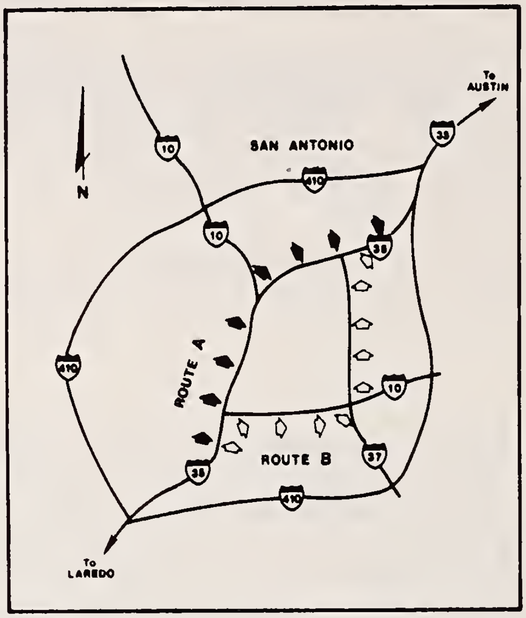
Enclosure

NOTE: We obtained your address from a license plate survey conducted on I-35. It is possible that we may have misread the license. If so, please ignore this letter.

Fiqure 41 - Example Cover Letter

State Department of Highways an Public Transportation

Route Preference Questionnaire



You may want to refer to the above map of the San Antonio area when answering the following questions.

1. Not including the trip you made on Friday, September 23, 1977, how often do you take I-35 (Route A) to travel northbound through San Antonio? Check one.

   ☐ 1-5 times per week
   ☐ 1-3 times per month
   ☐ Less than once a month
   ☐ Never before

2. How often do you take I-10 and I-37 (Route B) to travel northbound through San Antonio, Check one.

   ☐ 1-5 times per week
   ☐ 1-3 times per month
   ☐ Less than once a month
   ☐ Never before

Figure 42 - "Before" Questionnaire for Route A Motorists

3. How do you decide which of the two routes to take?

____

____

____

____

____

4. At the time your vehicle was observed traveling northbound through the city, what was the purpose of your trip? Check one.

- ☐ Going to or from work or school
- ☐ Pleasure or recreation
- ☐ Shopping
- ☐ Personal business
- ☐ Other ______________

5. Where did this trip begin? (Give either the Zip Code or a nearby major intersection; please list the city if other than San Antonio.)

____

____

____

6. What was your destination? (Give either the Zip Code or a nearby major intersection; please list the city if other than San Antonio.)

____

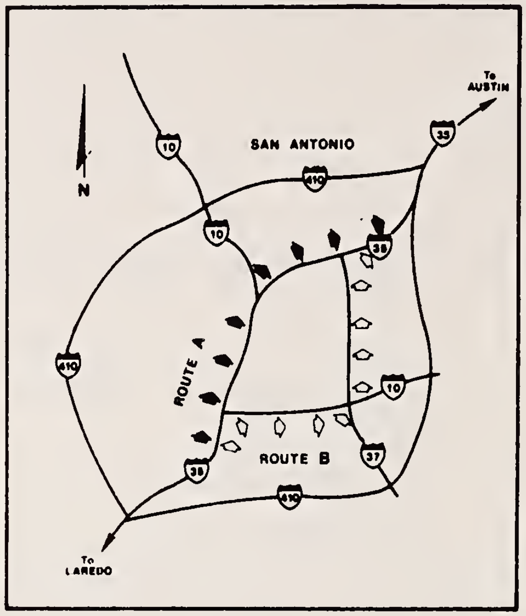
____

____

Thank you for your help. Please feel free to write additional comments in the space below.

State Department of Highways and Public Transportation

Route Preference Questionnaire



You may want to refer to the above map of the San Antonio area when answering the following questions.

1. Not including the trip you made on Friday, September 23, 1977, how often do you take I-10 and I-37 (Route B) to travel northbound through San Antonio? Check one.

   - [ ] 1-5 times per week
   - [ ] 1-3 times per month
   - [ ] Less than once a month
   - [ ] Never before

2. How often do you take I-35 (Route A) to travel northbound through San Antonio? Check one.

   - [ ] 1-5 times per week
   - [ ] 1-3 times per month
   - [ ] Less than once a month
   - [ ] Never before

Figure 43 - "Before" Questionnaire for Route B Motorists

3. How do you decide which of the two routes to take?

____

____

____

____

____

4. At the time your vehicle was observed traveling northbound through the city, what was the purpose of your trip? Check one.

- ☐ Going to or returning from work or school
- ☐ Pleasure or recreation
- ☐ Shopping
- ☐ Personal Business
- ☐ Other ______________

5. Where did this trip begin? (Give either the Zip Code or a nearby major intersection; please list the city if other than San Antonio.)

____

____

____

6. What was your destination? (Give either the Zip Code or a nearby major intersection; please list the city if other than San Antonio.)

____

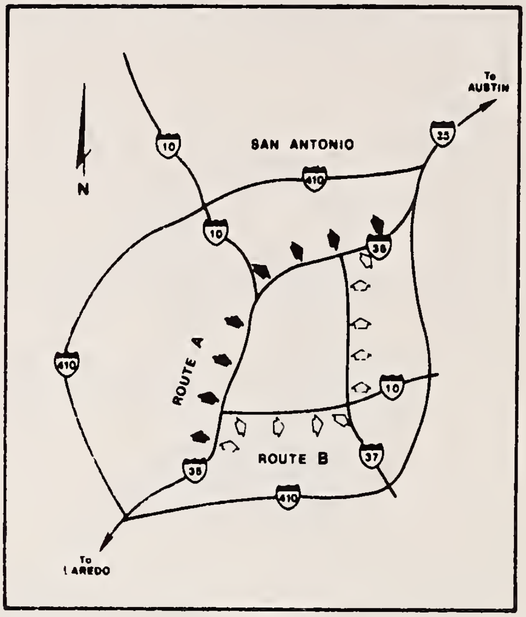
____

____

Thank you for your help. Please feel free to write additional comments in the space below.

State Department of Highways and Public Transportation

Route Preference Questionnaire



You may want to refer to the above map of the San Antonio area when answering the following questions.

1. Not including the trip you made on Friday, January 13, 1978, how often do you take Route A (see map) to travel northbound through San Antonio? Check one.

☐ 1-5 times per week ☐ Less than once a month
☐ 1-3 times per month ☐ Never before

2. How often do you take Route B (see map) to travel northbound through San Antonio? Check one.

☐ 1-5 times per week ☐ Less than once a month
☐ 1-3 times per month ☐ Never before

3. Which of the two routes do you prefer to drive?

☐ Route A ☐ Route B ☐ No Preference

If you indicated a preference, please explain why you prefer that route.

____

____

Figure 44 - "After" Questionnaire for Route A Motorists

4. "Have you had any problems following the freeway signs for either route?"

☐ Yes ☐ No

If "yes," please explain.

____

____

____

5. At the time your vehicle was observed traveling northbound through the city, what was the purpose of your trip? Check one.

☐ Going to or from work or school ☐ Pleasure or recreation

☐ Shopping ☐ Personal business ☐ Other ________

6. Where did this trip begin? (Give either the zip code or a nearby major intersection; please list the city if other than San Antonio).

____

____

____

7. What was your destination? (Give either the zip code or a nearby major intersection/please list the city of other than San Antonio).

____

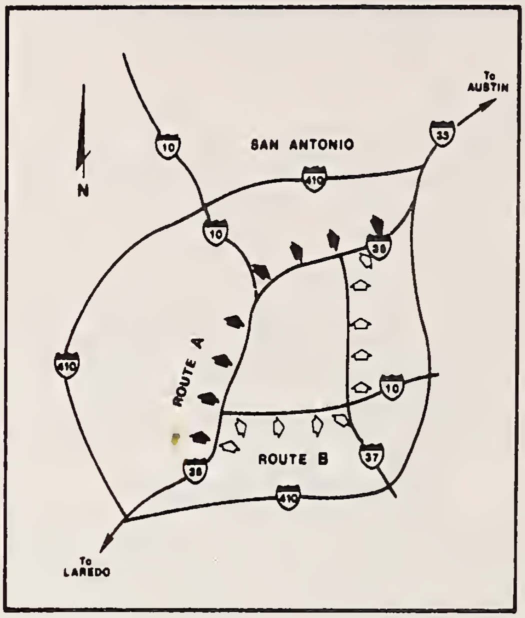
____

____

Thank you for your help. Please feel free to write additional comments in the space below.

State Department of Highways and Public Transportation

Route Preference Questionnaire



You may want to refer to the above map of the San Antonio area when answering the following questions.

1. Not including the trip you made on Friday, January 13, 1978, how often do you take Route B (see map) to travel northbound through San Antonio? Check one.

   ☐ 1-5 times per week ☐ Less than once a month
   ☐ 1-3 times per month ☐ Never before

2. How often do you take Route A (see map) to travel northbound through San Antonio? Check one.

   ☐ 1-5 times per week ☐ Less than once a month
   ☐ 1-3 times per month ☐ Never before

3. Which of the two routes do you prefer to drive?

   ☐ Route A ☐ Route B ☐ No Preference

   If you indicated a preference, please explain why you prefer that route.

   ____

   ____

Figure 45 - "After" Questionnaire for Route B Motorists

4. 'Have you had any problems following the freeway signs for either route?"

☐ Yes ☐ No

If "yes," please explain.

____

____

____

5. At the time your vehicle was observed traveling northbound through the city, what was the purpose of your trip? Check one.

☐ Going to or from work or school ☐ Pleasure or recreation

☐ Shopping ☐ Personal business ☐ Other __________

6. Where did this trip begin? (Give either the zip code or a nearby major intersection; please list the city if other than San Antonio).

____

____

____

7. What was your destination? (Give either the zip code or a nearby major intersection/please list the city of other than San Antonio).

____

____

____

Thank you for your help. Please feel free to write additional comments in the space below.

APPENDIX D

CHARACTERISTICS OF THRU DRIVERS BEFORE AND AFTER I-35 RE-ROUTING

Objectives

The objectives of this portion of the study were to determine the characteristics of thru drivers in terms of:

1. typical origins and destinations, and
2. familiarity of alternative freeway routes around the downtown area.

Approach

Questionnaires were mailed before and after the sign changes by the SDHPT to northbound thru drivers identified from the license plate studies. The questionnaires were coded by study time periods and driver travel route. The "after" questionnaire, in addition to the above objectives, was also designed to query drivers as to whether they had any problems following the freeway guide signs through the study area. Copies of each questionnaire and an example of a cover letter were shown in Appendix C.

Addresses of the thru drivers were obtained from the SDHPT Motor Vehicles Division. Unfortunately, addresses for out-of-state residents could not be obtained. In addition, questionnaires were not mailed to businesses and car rental companies because of the difficulty in establishing the actual driver of the vehicle. The lack of information from out-of-state drivers most likely biases results toward the more familiar driver.

It should be noted that the volume of license plate data that had to be reduced from the audio tapes (45,000 plate numbers from the "before" study and 130,000 from the "after" study) dictated a relatively lengthy time between the conduct of the study and the receipt of questionnaires by the drivers. This lag time (6-8 weeks) may have diminished individual driver's ability to recall some particulars of the trip he made on the study day. Some of these deficiencies were anticipated in the analysis of questionnaire data.

Results

Response Rate

Table 21 summarizes the driver questionnaire response rates. The first column in Table 21 represents the number of thru drivers adjusted due to errors in license plate counts and matches.

TABLE 21

QUESTIONNAIRE RESPONSE RATES

	Before Study Periods	After Study Periods
1. Number of Thru Drivers from License Plate Matches	1401	1483
2. Number of Thru Drivers (Adjusted)*	1590	1753
3. Number of Questionnaires mailed	1198	1291
4. Number of Questionnaires Delivered	1142	1204
5. Number of Completed Questionnaires Received	408	424
Effective Percent Response Rate (#5 ÷ #4)	36	35
Effective Percent of Thru Drivers Surveyed (#5 ÷ #2)	25	24

*From Tables 15 and 18. It should be noted that the 1753 drivers for the "after" study is greater than the 1656 value shown in Table 6. This is due to the fact that one tape recorder, used at the origin station to record license plate numbers on one of the lanes was not functional. Thus additional license plate numbers from the other lanes, matched between 4:39 and 5:00 pm, were available for the questionnaire survey. However, these data could not be used to estimate percentages of thru drivers shown in Table 18.

Column 2 represents the actual number of questionnaires mailed by the SDHPT. The number of questionnaires actually delivered to drivers is shown in Column 3. These values reflect the fact that some of the questionnaires were returned to the SDHPT as undeliverable due to changes of addresses or incorrect addresses in the filing system. Column 4 lists the number of questionnaires completed by the drivers and returned to the SDHPT.

The results in Table 21 show that the percent of deliverable questionnaires completed by the drivers and returned to the SDHPT--the effective response rate--was 36% for the before study and 35% for the after study. The results also show that 25% of the estimated number of thru drivers during the before study periods were interviewed, compared to 24% for the after study. In effect, the percent of thru drivers surveyed during each study was essentially the same.

Frequency of Route Usage

Questions 1 and 2 were included in the questionnaires with the belief that the usage frequency of the two routes would reflect driver familiarity of each route, which would then give some clues as to the characteristics of drivers switching to the diversion route after the sign changes. Drivers were asked to indicate how often they used each route. It may be inferred that drivers who traveled the route 1-5 times per week could be considered as very familiar drivers, those using the facility 1-3 times per month as familiar drivers, less than once a month as somewhat familiar, and never before as unfamiliar.

Table 22 summarizes driver familiarity based on the frequency of route usage. There was a 5% reduction in the proportion of thru drivers who may be considered very familiar or familiar with both routes (62% before, 57% after) with a corresponding 5% increase in the proportion of drivers somewhat familiar and unfamiliar with both routes (9% vs 14%). Since the freeway sign changes were directed at the thru drivers less familiar with the routes, the data indicate that the increased usage of the diversion route by the thru drivers after the sign changes was a result of a greater percentage of less familiar drivers traveling thru the city during the after study. This indicates that sign changes were successful in attracting thru drivers to the diversion route.

Local vs. Non-Local Drivers

Another analysis was performed to determine the type of drivers (i.e., local or non-local) traveling thru the city who shifted to the diversion route. As previously discussed, addresses of all thru drivers determined from the license plate surveys were obtained from the SDHPT Motor Vehicle Division. Since the license plate studies provided data as to which route drivers selected, plate numbers on each route could be matched with the addresses of the drivers. Those drivers residing in Bexar County were categorized as local drivers; whereas, those living outside Bexar County were categorized as non-local drivers. Even though addresses were not obtained for out-of-state

TABLE 22

ASSUMED DRIVER FAMILIARITY BASED ON
FREQUENCY OF ROUTE USAGE

Before Sign Changes (N=394)

Diversion Route \ Primary Route	Very Familiar - Familiar	Somewhat Familiar - Unfamiliar
Very Familiar - Familiar	62%	8%
Somewhat Familiar - Unfamiliar	21%	9%

After Sign Changes (N=405)

Diversion Route \ Primary Route	Very Familiar - Familiar	Somewhat Familiar - Unfamiliar
Very Familiar - Familiar	57%	8%
Somewhat Familiar - Unfamiliar	21%	14%

drivers, the mere fact that the license plate numbers were available allowed these drivers to be included in the analysis. Thus, the analysis includes all the license plate matches (thru drivers) for both the before and after studies.

The results revealed that there was a definite shift to the diversion route and that the shift was being made primarily by non-local drivers. Table 23 shows that prior to the sign changes, 22% of the thru drivers traveled on the diversion route (20% local and 2% non-local). After the sign changes, the diversion route carried 26% of the thru drivers (19% local and 7% non-local drivers).

The route selection, based on driver residence, is more clearly reflected in Table 24. Prior to the sign changes, 25% of the local drivers traveling thru the study area chose the diversion route. After the sign changes, 24% select the route--a slight but probably insignificant increase toward the primary. The results, however, show a definite increase in non-local drivers on the diversion route. Prior to the sign changes, 10% traveled on the diversion route after the sign changes, 33% traveled on the route.

Typical O-D Patterns

Questions 5 and 6 in the before and 7 and 8 in the after questionnaires were designed to establish typical O-D patterns of the drivers traveling thru the study area. Unfortunately, there was a considerable amount of inconsistency in the data and therefore, the O-D patterns could not be established. For example, some drivers who were observed from the license plate survey to be passing thru the study area stated they did not. The speculation is that since many of the drivers surveyed were residents of Bexar County and utilized the freeway system regularly, they may not have remembered the specific trip in question, particularly since they did not receive the questionnaire until two months following the trip. Another factor compounding the analysis problem was that the out-of-state drivers could not be surveyed through the questionnaire.

Problems in Following Freeway Signs

Question 4 in the after questionnaire was intended to obtain driver input related to problems in following the freeway signs through the city. Only 33 drivers out of 424 stated they had problems and gave comments about the signs. Most of the comments related to freeway signing in general in San Antonio. A listing of the comments received is presented in Appendix E.

TABLE 23

DISTRIBUTION OF THRU TRIPS BASED ON DRIVER RESIDENCE

Before Sign Changes (N=1401)

Route	Local Drivers	Non-Local Drivers	Total
Primary Route	59%	19%	78%
Diversion Route	20%	2%	22%
TOTALS	79%	21%	100%

After Sign Changes (N=1483)

Route	Local Drivers	Non-Local Drivers	Total
Primary Route	60%	14%	74%
Diversion Route	19%	7%	26%
TOTALS	79%	21%	100%

TABLE 24

ROUTE CHOICE BY DRIVER RESIDENCE

Non-Local Drivers

Route	Before Sign Change	After Sign Change
Primary Route	90%	67%
Diversion Route	10%	33%
	100% (N = 298)	100% (N = 317)

Local Drivers

Route	Before Sign Change	After Sign Change
Primary Route	75%	76%
Diversion Route	25%	24%
	100% (N = 1103)	100% (N = 1166)

APPENDIX E

DRIVER COMMENTS ON
PROBLEMS IN FOLLOWING FREEWAY SIGNS

Drivers on Primary Route (Route A)

1. When you come from the south, there is no sign saying IH-37; that is why I used to take Route A, because I didn't know the other.

2. Going into San Antonio on 35 south you have the 35's on the board on left side of road when you hit the interchange the 35's sign is on the right side of the road to go 35 and 37S.

3. Since both signs say that they lead to the same place (I think!).

4. That is how we ended up on Route A - missed the signs for Route B.

5. I did not know that Route B would take you to Interstate 35.

6. 10 East onto 35N very confusing.

7. The I-37 South slips up on you with the new I-35/37 North-Austin being more prominent. I missed 37S the first time I went that way from US90/ I-10.

8. If you were not familiar with town you want to go I-35 to I-37 and back to I-35 since sign changes and not be able to locate locations in between.

9. Signs are too close to intersections, not enough warning.

10. Some of the signs are too close to the exits, don't give you enough time get out, for people traveling through San Antonio.

11. Some of the signs are not far enough back from exit or turn-off intersections. I find in several places where motorists do not have sufficient advance notice for interchange's, safety to execute.

12. Occasionally get forced onto IH-10 because of insufficient warning of upcoming exit from IH-35 to IH-10(W). Understandable attempt to reduce downtown traffic on IH-35-10; however, anyone with a map of San Antonio would take the more direct route "a" over "b" even though the distance saved is minimal.

13. When I first started traveling from the southwest part of town I found myself circling the city to get to I-10 north because I thought I-35 went to I-10 north.

14. Having one big sign with two directions on it. It would be safer to have 2 signs, one for each direction. I would like to compliment the expressway 37. It is the best way to go in the San Antonio area. I feel that there is not quite enough indication of the right lane becoming only an exit. There should be a sign or signs for each entrance to have thru traffic moved to the extreme left.

15. The recent route # change was confusing and not necessary - prefer old route.

    When I wanted San Antonio college, I understood to find the San Pedro exit. The signs messed me up because I found 37 and 35 to be the same road for a while when coming off of 10. A friend of mine later complained to me that the same happened to him.

17. Southbound at IH35 and IH37 junction, I missed signs and ended up on IH37 not IH35 South.

18. There should be some advance signs as in other large cities.

19. When I first moved to San Antonio the signs were very confusing to me - possibly because 35, 37, and 410 were one and the same in certain places at that time.

20. IH35 is always jam on my way to work (north) and I've seen more accidents occur on this freeway.

21. Going north on 35 to get off and catch McAllister on extension of 37 (which should be more clearly identified) a real traffic hazard is caused by the St. Mary's North exit upon 35.

22. Traveling south on McAllister Freeway to intersect Route A, I twice missed the right-hand exit lane because the IH-35S sign was changed to another number. Could Route A's highway number be changed to "Business IH-35?" The new number is confusing when someone is looking for the old one.

23. People from out of town do not know what McAllister Freeway is.

24. Downtown where branch off to El Paso and IH-10.

25. Signs are old, hard to read, and don't give enough time to react.

26. They not easy to see when traffic is heavy.

Drivers on Diversion Route (Route B)

1. Route B Southbound. Exit signs marked "Laredo" very difficult to follow. Suggest Signs at intersection of IH-10 and IH-35 be made clear. It is

difficult to determine which lane is exit lane. Northbound exits well marked. Only southbound difficult.

2. Southbound one can end up headed to Kelly AFB instead of IH-35 if they are not paying close attention to the signs.

3. I seem to find myself in the wrong lane when I get to the exit I want to turn off on Route A. The exit signs do not seem to be in the order I expect them to be and if the exit proves to be to the left instead of the right, I will miss it every time. I do not know if I am not reading the pattern right or if the signs are not in the usual order. I do not seem to have the problem on other routes.

4. Often find myself in wrong lane to change from I-35 to I-10.

5. Too many exit ramps for what is supposedly a thru route (I-35). That is, have to get off onto I-10, then onto I-35, then back onto I-35 again.

6. Being new in town in January, did not know that while a sign showed "35 south", there is no "35 north" at that point (just 81 or 87 north). Very confusing for a new person in town who knows how to read a map. Just the problem of confusion that a San Antonio map shows 35 and 81 with 37 a few miles east, but while traveling east on 90, see 35 south, expect next to to be 35 north; instead, see 81 or 87 north business. To add to confusion, a few miles east see 35 N and 37 N. Took a few trips downtown and talk with local people to learn what's going on. But now I like 35 N from 90 W for downtown.

7. I miss signs because of the concentration required to avoid an accident.

APPENDIX F

I-35 RE-ROUTING EFFECTS ON FREEWAY TRAFFIC VOLUMES-
STUDY APPROACH

Objectives

The purpose of these studies was to estimate the long-term effects of the sign changes in terms of total volume changes on the primary and diversion routes. Whereas the studies previously discussed focused on northbound I-35 unfamiliar drivers traveling thru the city, this study was designed to assess additional impacts such as the increased use of the diversion route by US-90 and I-10 traffic and by local drivers who now recognized the attractiveness of the new route.

Approach

The overall impact on the primary and diversion routes was assessed by analyzing volume data from automatic traffic counters located within the study area. In addition to four permanent SDHPT traffic counters (two on each route) located within the study area, four new counters were installed. One was positioned on northbound I-35 near Theo Avenue upstream from the I-35/I-10/ US-90 interchange. The other three counters were installed on the interchange ramps along Route B--the I-35/I-10E, I-10/I-37, and I-37,I-35 interconnect ramps. The locations of the counters are shown in Figure 46.

A variety of traffic volume counts from the permanent SDHPT counters were analyzed over a two-year period, including four months after the signs were changed. It was envisioned that ramp volumes might be more sensitive to the relatively small volume changes (in comparison to total freeway volumes) expected after the signs were changed. Unfortunately, unavoidable delays in equipment installation and occasional hardware malfunctions limited the usefulness of the data from the ramp locations.

Because there was a considerable delay in obtaining the counters from the manufacturer, the SDHPT installed some of their counters at the necessary locations. Unfortunately, prior commitments for the use of the counters required that they be removed to other locations at irregular intervals. While these counters were in place in the study area, there were equipment malfunctions that further reduced the adequacy of the data obtained.

A thorough analysis was performed on all data received. Apparently, the extreme variability in ramp volumes overshadowed any change that could be attributed to the redesignation. This variability, coupled with limited data availability, provided inconclusive results regarding the effect of the sign changes.

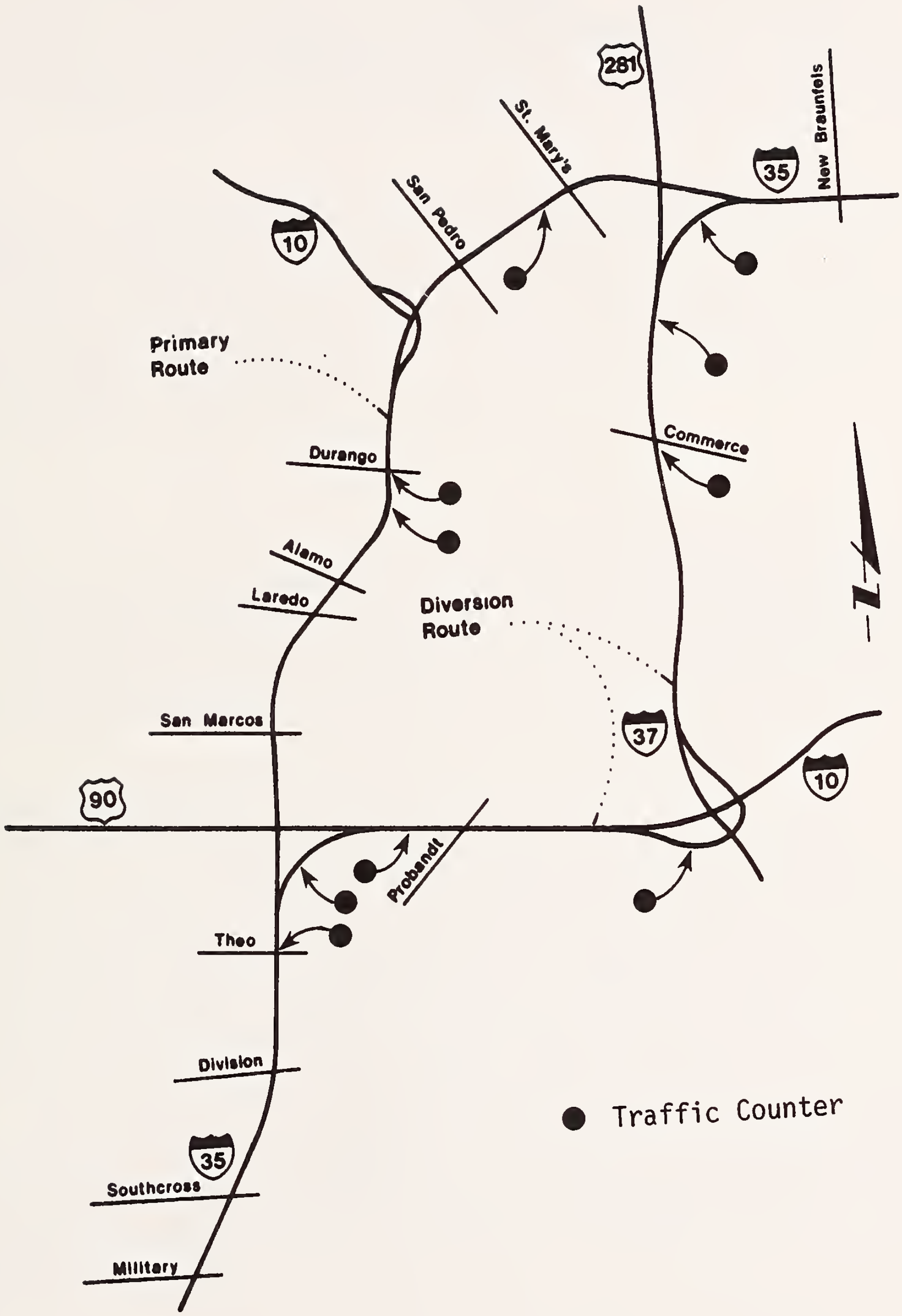


Figure 46 - Automatic Counter Locations

Another mitigating factor was that before and after studies were conducted out of necessity during months in which the number of non-local drivers was relatively low in comparison to other months, particularly the summer. In the opinion of the authors, the amount of thru traffic using the diversion route will most likely be higher in the summer months than what was measured in January. Again, a more extensive O-D survey during the summer would enhance the evaluation of the sign changes.

APPENDIX G

SIGN OPERATION REVIEW
FOR SAN ANTONIO POLICE DISPATCHERS

General

The purpose of the emergency warning sign system installed on I-35 northbound between Military Drive and Division Avenue is to advise motorists of freeway conditions ahead and, when conditions warrant, to advise them of alternate routes available to bypass congestion resulting from accidents or freeway blockages. The attached tables describe the messages available for display and provide a quick reference guide to the appropriate message for various conditions. Also included is a guide to the Display Numbers for each sign that correspond to each Message Number.

Message List

Attachment A shows the messages contained in the computer memory of each sign. For greatest effectiveness, the signs must be used in combination. Thus, each message combination is assigned an individual Message Number. Sign 1 is the first sign the northbound driver will see, and is located just south of the Southcross exit. Sign 2 is just south of the Division exit.

Message Selection Guide

Attachment B is an index or reference guide to the messages available on Attachment A. Based on the location of the accident or blockage and the location to which traffic is backed up, the officer can readily select the Message Number most appropriate for the conditions. There are four sheets in Attachment B, each relating to a different time of day (A.M. Peak or Off-Peak) or to number of lanes blocked (1-lane Blocked or All Lanes Blocked). This guide has been prepared in coordination with Captain Nichols and the staff of the Traffic Division. The officer is encouraged to use this guide to his maximum advantage. There may be occasions when the officer in the field feels that some message other than the one recommended would be better. He is encouraged to go with his best judgment. However, since this is a research project, decisions to deviate from the guide should be briefly explained on the report to the Accident Prevention Bureau so that overall operation of the signs can be evaluated and improved.

Special Situations

The officer's attention is called to some special situations. In Attachment B there is more than one message option for accidents occurring at, or south of, the interchange with IH-10 East. The Message Numbers in parentheses refer to general messages that do not state which lane is blocked. The

numbers separated by an "*" refer to messages stating which lane is blocked. "LEFT LANE BLOCKED" messages are the left numbers in each square and "RIGHT LANE BLOCKED" are the right Message Numbers. For example, an accident blocking one lane of IH-10E during the A.M. Peak (page 1) with traffic backed up to Division would require either Message Numbers 46, 47, or 50 (see Attachment A for message content of each).

Pages 3 and 4 of Attachment B contain an additional option for conditions requiring closure of the freeway by police personnel. The smaller number in each square (Message Numbers 6, 7, 8, and 9) change the sign displays from an advisory message to a requirement to exit at IH-10E or US-90. Compare the Message Numbers in the various squares to see how message content changes. It should be emphasized that Messages 6 thru 9 are used only when police forces physically close the freeway at IH-10E.

Dispatcher's Guide to Display Numbers

Although it is important for the Dispatcher to understand the field operations discussed above, as sign operator, he will work primarily with Attachment C. This guide identifies the Display Numbers that must be input to each sign to form the complete message described by a Message Number. The procedure for displaying messages is outlined in the next section.

Message Display Procedure

Attachment D describes the procedures necessary to display and to blank messages. It should be emphasized that both signs should be used together to avoid conflicting information.

Special Instructions

Case Numbers--In addition to the input of time of display (as part of the display procedures), it is also important for the dispatcher to write either the case number or the date on the teletype printout. This will be used to tie the information displayed to a particular incident.

Rub-Out Feature--There may be occasions where the dispatcher inadvertently types the wrong letter or number on the teletype and realizes the mistake before a message is displayed. If this happens, the "RUB OUT" button on the right side of the keyboard can be used to correct the mistake. This button should be pressed once for each character or space that is incorrect. This essentially backspaces to let the dispatcher start over anywhere he chooses. Once the incorrect inputs have been "rubbed out" the correct inputs can be made without further changes.

Reset Timing--If power to the signs goes out, the time clock in the sign computer will stop. When the "T" and "RETURN" buttons are pressed, the teletype will print out the time on the time clocks followed by "NEW TIME ." If

the time shown is incorrect, type in the new time in Hours, Minutes, Seconds, and AM or PM. For example:

8:42:01AM NEW TIME > 11:14:00PM.

Any questions regarding these special instructions should be forwarded to Sgt. Abate.

In order to effectively operate this emergency warning sign system and to make improvements that will undoubtedly be necessary, the input from all officers is vital. Please forward any and all suggestions to Sgt. Abate.

MESSAGES

Message Number	Sign 1	Sign 2	Message Number	Sign 1	Sign 2
1	SLOW TRAFFIC AHEAD BE PREPARED TO STOP		21	ACCIDENT AT COMMERCE	ACCIDENT AT COMMERCE
2		SLOW TRAFFIC AHEAD BE PREPARED TO STOP	22	ACCIDENT AT COMMERCE	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
3	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	23	ACCIDENT AT COMMERCE DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
4	ACCIDENT AHEAD BE PREPARED TO STOP	ACCIDENT AHEAD BE PREPARED TO STOP	24	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT COMMERCE DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
5	ACCIDENT NORTH OF I-10E	ACCIDENT NORTH OF I-10E	25	ACCIDENT AT COMMERCE DOWNTOWN USE IH-10 / IH-37	ACCIDENT AT COMMERCE DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
6	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AHEAD ALL TRAFFIC MUST EXIT IH-10 EAST--US 90 WEST	26	ACCIDENT AT DURANGO	ACCIDENT AT DURANGO
7	FWY BLOCKED AHEAD ALL TRAFFIC MUST EXIT IH-10 EAST--US 90 WEST	FWY BLOCKED AHEAD ALL TRAFFIC MUST EXIT IH-10 EAST--US 90 WEST	27	ACCIDENT AT DURANGO	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
8	FWY CLOSED AT IH-10E--US-90 ALL TRAFFIC MUST EXIT	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	28	ACCIDENT AT DURANGO DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
9	FWY CLOSED AT IH-10E--US-90 ALL TRAFFIC MUST EXIT	FWY CLOSED AT IH-10E--US-90 ALL TRAFFIC MUST EXIT	29	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT DURANGO DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
10	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	30	ACCIDENT AT DURANGO DOWNTOWN USE IH-10 / IH-37	ACCIDENT AT DURANGO DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
11	ACCIDENT AT ST. MARYS	ACCIDENT AT ST. MARYS	31	ACCIDENT AT ALAMO ST.	ACCIDENT AT ALAMO ST.
12	ACCIDENT AT ST. MARYS	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	32	ACCIDENT AT ALAMO ST.	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
13	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	33	ACCIDENT AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
14	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	34	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
15	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-10 / IH-37	ACCIDENT AT ST. MARYS DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	35	ACCIDENT AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37	ACCIDENT AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
16	ACCIDENT AT IH-10 WEST	ACCIDENT AT IH-10 WEST	36	ACCIDENT AT LAREDO ST.	ACCIDENT AT LAREDO ST.
17	ACCIDENT AT IH-10 WEST	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	37	ACCIDENT AT LAREDO ST.	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
18	ACCIDENT AT IH-10 WEST DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	38	ACCIDENT AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
19	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT IH-10 WEST DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	39	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
20	ACCIDENT AT IH-10 WEST DOWNTOWN USE IH-10 / IH-37	ACCIDENT AT IH-10 WEST DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	40	ACCIDENT AT LAREDO ST. DWTN TRAFFIC USE I-10/I-37	ACCIDENT AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY

Message Number	Sign 1	Sign 2
41	ACCIDENT AT STOCKYARO	ACCIDENT AT STOCKYARD
42	ACCIOENT AT STOCKYARD	DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR OELAY
43	ACCIOENT AT STOCKYARD OOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
44	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT STOCKYARD DOWNTOWN USE IH-1D / IH-37 AVOIO MAJOR OELAY
45	ACCIOENT AT STOCKYARO DOWNTOWN USE IH-1D / IH-37	ACCIOENT AT STOCKYARO DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
46	ACCIOENT AT IH-1D EAST	ACCIDENT AT IH-1D EAST
47	ACCIDENT AT IH-1D EAST LEFT LANE BLOCKED	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
4B	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIDENT AT IH-1D EAST LEFT LANE BLOCKED
49	ACCIDENT AT IH-1D EAST LEFT LANE BLOCKED	ACCIDENT AT IH-10 EAST LEFT LANE BLOCKEO
5D	ACCIDENT AT IH-10 EAST RIGHT LANE BLOCKED	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
51	SLOW TRAFFIC AHEAD BE PREPAREO TO STOP	ACCIOENT AT IH-10 EAST RIGHT LANE BLOCKEO
52	ACCIOENT AT IH-10 EAST RIGHT LANE BLOCKEO	ACCIDENT AT IH-1- EAST RIGHT LANE BLOCKED
53	ACCIOENT AT THEO	ACCIOENT AT THEO
54	ACCIOENT AT THEO LEFT LANE BLOCKED	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
55	SLOW TRAFFIC AHEAO BE PREPAREO TO STOP	ACCIDENT AT THEO LEFT LANE BLOCKED
56	ACCIOENT AT THEO LEFT LANE BLOCKED	ACCIDENT AT THEO LEFT LANE BLOCKEO
57	ACCIOENT AT THEO RIGHT LANE BLOCKED	SLOW TRAFFIC AHEAO BE PREPARED TO STOP
58	SLOW TRAFFIC AHEAO BE PREPARED TO STOP	ACCIDENT AT THEO RIGHT LANE BLOCKED
59	ACCIDENT AT THEO RIGHT LANE BLOCKEO	ACCIOENT AT THEO RIGHT LANE BLOCKED
60	ACCIOENT AT OIVISION	ACCIDENT AT OIVISION
61	ACCIOENT AT OIVISION LEFT LANE BLOCKED	SLOW TRAFFIC AHEAO BE PREPARED TO STOP
62	SLOW TRAFFIC AHEAO BE PREPAREO TO STOP	ACCIDENT AT OIVISION LEFT LANE BLOCKED
63	ACCIDENT AT DIVISION LEFT LANE BLOCKED	ACCIDENT AT OIVISION LEFT LANE BLOCKED
64	ACCIDENT AT DIVISION RIGHT LANE BLOCKED	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
65	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	ACCIOENT AT OIVISION RIGHT LANE BLOCKED
66	ACCIDENT AT DIVISION RIGHT LANE BLOCKED	ACCIOENT AT OIVISION RIGHT LANE BLOCKEO
67	ACCIDENT AT SOUTHCROSS	
6B	ACCIOENT AT SOUTHCROSS LEFT LANE BLOCKED	
69	ACCIOENT AT SOUTHCROSS CENTER LANE BLOCKED	
7D	ACCIDENT AT SOUTHCROSS RIGHT LANE BLOCKED	
71	FWY BLOCKEO AT ST. MARYS	FWY BLOCKEO AT ST. MARYS
72	FWY BLOCKED AT ST. MARYS	DOWNTOWN USE IH-1D / IH-37 AVOID MAJOR OELAY
73	FWY BLOCKED AT ST. MARYS OOWNTOWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAO BE PREPAREO TO STOP
74	SLOW TRAFFIC AHEAO BE PREPARED TO STOP	FWY BLOCKEO AT ST. MARYS DOWNTOWN USE IH-1D / IH-37 AVOIO MAJOR DELAY
75	FWY BLOCKEO AT ST. MARYS DOWNTOWN USE IH-1D / IH-37	FWY BLOCKED AT ST. MARYS OOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
76	FWY BLOCKED AT IH-10 WEST	FWY BLOCKEO AT IH-1D WEST
77	FWY BLOCKED AT IH-10 WEST	OOWNTOWN USE IH-1D / IH-37 AVOID MAJOR OELAY
7B	FWY BLOCKED AT IH-10 WEST OOWNTOWN USE IH-1D / IH-37	SLOW TRAFFIC AHEAO BE PREPAREO TO STOP
79	SLOW TRAFFIC AHEAO BE PREPARED TO STOP	FWY BLOCKEO AT IH-10 WEST OOWNTOWN USE IH-10 / IH-37 AVOIO MAJOR DELAY
BD	FWY BLOCKEO AT IH-10 WEST OOWNTOWN USE IH-1D / IH-37	FWY BLOCKEO AT IH-10 WEST OOWNTOWN USE IH-1D / IH-37 AVOIO MAJOR OELAY

Message Number	Sign 1	Sign 2	Message Number	Sign 1	Sign 2
81	FWY BLOCKED AT COMMERCE	FWY BLOCKED AT COMMERCE	101	FWY BLOCKED AT STOCKYARD	FWY BLOCKED AT STOCKYARD
82	FWY BLOCKED AT COMMERCE	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	102	FWY BLOCKED AT STOCKYARD	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
83	FWY BLOCKED AT COMMERCE DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	103	FWY BLOCKED AT STOCKYARD DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
84	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT COMMERCE DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	104	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT STOCKYARD DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
85	FWY BLOCKED AT COMMERCE DOWNTOWN USE IH-10 / IH-37	FWY BLOCKED AT COMMERCE DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	105	FWY BLOCKED AT STOCKYARD DOWNTOWN USE IH-10 / IH-37	FWY BLOCKED AT STOCKYARD DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
86	FWY BLOCKED AT DURANGO	FWY BLOCKED AT DURANGO	106	FWY BLOCKED AT IH-10 EAST	FWY BLOCKED AT IH-10 EAST
87	FWY BLOCKED AT DURANGO	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	107	FWY BLOCKED AT IH-10 EAST	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY
88	FWY BLOCKED AT DURANGO DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	108	FWY BLOCKED AT IH-10 EAST	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
89	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT DURANGO DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	109	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT IH-10 EAST
90	FWY BLOCKED AT DURANGO DOWNTOWN USE IH-10 / IH-37	FWY BLOCKED AT DURANGO DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	110		
91	FWY BLOCKED AT ALAMO ST.	FWY BLOCKED AT ALAMO ST.	111	FWY BLOCKED AT THEO	FWY BLOCKED AT THEO
92	FWY BLOCKED AT ALAMO ST.	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	112	FWY BLOCKED AT THEO	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
93	FWY BLOCKED AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	113	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT THEO USE ACCESS RD FOR BYPASS
94	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	114	FWY BLOCKED AT THEO USE ACCESS RD FOR BYPASS	FWY BLOCKED AT THEO USE ACCESS RD FOR BYPASS
95	FWY BLOCKED AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37	FWY BLOCKED AT ALAMO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	115	FWY BLOCKED AT DIVISION	FWY BLOCKED AT DIVISION
96	FWY BLOCKED AT LAREDO ST.	FWY BLOCKED AT LAREDO ST.	116	FWY BLOCKED AT DIVISION	SLOW TRAFFIC AHEAD BE PREPARED TO STOP
97	FWY BLOCKED AT LAREDO ST.	DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	117	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT DIVISION USE ACCESS RD FOR BYPASS
98	FWY BLOCKED AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	118	FWY BLOCKED AT DIVISION USE ACCESS RD FOR BYPASS	FWY BLOCKED AT DIVISION USE ACCESS RD FOR BYPASS
99	SLOW TRAFFIC AHEAD BE PREPARED TO STOP	FWY BLOCKED AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	119	FWY BLOCKED AT SOUTHCROSS	
100	FWY BLOCKED AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37	FWY BLOCKED AT LAREDO ST. DOWNTOWN USE IH-10 / IH-37 AVOID MAJOR DELAY	120	FWY BLOCKED AT SOUTHCROSS USE ACCESS RD FOR BYPASS	

ATTACHMENT B

MESSAGE SELECTION
PATROL GUIDE

A.M. Peak--1 Lane Blocked

ACCIDENT LOCATION

	North of I-10W	I-10W	Commerce	Durango	Alamo	Laredo	Stock Yards	I-10E	Theo	Division	Southcross
North of I-10W	11										
I-10W	11	16									
Commerce	12	16	21								
Durango	12	17	21	26							
Alamo	12	17	22	26	31						
Laredo	12	17	22	27	31	36					
Stock Yards	12	17	22	27	32	36	41				
I-10E	12	17	22	27	32	37	42	46			
Theo	13	18	23	28	33	38	43	(46) 47*50	(53) 54*57		
Division	13	18	23	28	33	38	43	(46) 47*50	(53) 54*57	(60) 61*64	
Southcross	14	19	24	29	34	39	44	(46) 48*51	(53) 55*58	(60) 62*65	(67) 68*69 70
	15	20	25	30	35	40	45	49*52	56*59	63*66	68*69*70

TRAFFIC BACKUP

Sign 2 →

Sign 1 →

MESSAGE SELECTION
PATROL GUIDE

OFF-PEAK--1 LANE BLOCKED

ACCIDENT LOCATION

TRAFFIC BACKUP	North of I-10W	I-10W	Commerce	Durango	Alamo	Laredo	Stock Yards	I-10E	Theo	Division	Southcross
North of I-10W	11										
I-10W	11	16									
Commerce	11	16	21								
Durango	11	16	21	26							
Alamo	11	16	21	26	31						
Laredo	11	16	21	26	31	36					
Stock Yards	12	17	22	27	32	37	(41) 42				
I-10E	12	17	22	27	32	37	42	46			
Theo	13	18	23	28	33	38	43	(46) 47*50	(53) 54*57		
Division	13	18	23	28	33	38	43	47*50	54*57	(60) 61*64	
Sign 2 → Southcross	14	19	24	29	34	39	44	48*51	55*58	62*65	(67) 68*69 70
Sign 1 →	15	20	25	30	35	40	45	49*52	56*59	63*66	68*69*70

MESSAGE SELECTION
PATROL GUIDE

OFF-PEAK--ALL LANES BLOCKED

ACCIDENT LOCATION

TRAFFIC BACKUP

	North of I-10W	I-10W	Commerce	Durango	Alamo	Laredo	Stock Yards	I-10E	Theo	Division	Southcross
North of I-10W	71										
I-10W	71	76									
Commerce	71	76	81								
Durango	71	76	81	86							
Alamo	71	76	81	86	91						
Laredo	71	76	81	86	91	96					
Stock Yards	72*9	77*9	82*9	37*9	92*9	97*9	(101) 102*9				
I-10E	72*9	77*9	82*9	37*9	92*9	97*9	(101) 102*9	(106) 107*9			
Theo	73*8	78*8	83*8	88*8	93*8	98*8	103*8	108*8	(111) 112		
Division	73*8	78*8	83*8	88*8	93*8	98*8	103*8	108*8	112	(115) 116	
Southcross	74*6	79*6	84*6	89*6	94*6	99*6	104*6	109*6	113	117	119
	75*7	80*7	85*7	90*7	95*7	100*7	105*7	106	111 114	115 118	119 120

Sign 2

Sign 1

MESSAGE SELECTION
PATROL GUIDE

A.M. PEAK--ALL LANES BLOCKED

ACCIDENT LOCATION

TRAFFIC BACKUP	North of I-10W	I-10W	Commerce	Durango	Alamo	Laredo	Stock Yards	I-10E	Theo	Division	Southcross
North of I-10W	71										
I-10W	72	76									
Commerce	72	77	81								
Durango	72	77	82	87							
Alamo	72	77	82	87	92						
Laredo	72*9	77*9	82*9	87*9	92*9	97					
Stock Yards	72*9	77*9	82*9	87*9	92*9	97*9	(101) 107*9				
I-10E	72*9	77*9	82*9	87*9	92*9	97*9	102*9	(106) 107*9			
Theo	73*8	78*8	83*8	88*8	93*8	98*3	103*8	108*8	(111) 112		
Division	73*8	78*8	83*8	88*8	93*9	98*8	103*3	108*8	112	(115) 116	
Sign 2 → Southcross	74*6	79*6	84*6	89*6	94*6	99*6	104*6	109*6	113	117	119
Sign 1 →	75*7	80*7	85*7	90*7	95*7	100*7	105*7	106	111 114	115 118	119 120

CHANGEABLE MESSAGE SIGNS
DISPATCHER'S GUIDE

General Messages

Message Number	Sign 1	Sign 2
1	D- 1	D- 0
2	D- 0	D- 1
3	D- 1	D- 1
4	D- 2	D- 2
5	D- 3	D- 3
6	D- 1	D- 4
7	D- 4	D- 4
8	D- 5	D- 1
9	D- 5	D- 5
10	D- 6	D- 6

Sheet 1 of 3

CHANGEABLE MESSAGE SIGNS
DISPATCHER'S GUIDE

ACCIDENT--1 LANE BLOCKED

MESSAGE NUMBER	SIGN 1	SIGN 2
11	D- 7	D- 7
12	D- 7	D- 6
13	D- 8	D- 1
14	D- 1	D- 8
15	D- 8	D- 8
16	D- 9	D- 9
17	D- 9	D- 6
18	D-10	D- 1
19	D- 1	D-10
20	D-10	D-10
21	D-11	D-11
22	D-11	D- 6
23	D-12	D- 1
24	D- 1	D-12
25	D-12	D-12
26	D-13	D-13
27	D-13	D- 6
28	D-14	D- 1
29	D- 1	D-14
30	D-14	D-14

MESSAGE NUMBER	SIGN 1	SIGN 2
31	D-15	D-15
32	D-15	D- 6
33	D-16	D- 1
34	D- 1	D-16
35	D-16	D-16
36	D-17	D-17
37	D-17	D- 6
38	D-18	D- 1
39	D- 1	D-18
40	D-18	D-18
41	D-19	D-19
42	D-19	D- 6
43	D-20	D- 1
44	D- 1	D-20
45	D-20	D-20
46	D-21	D-21
47	D-22	D- 1
48	D- 1	D-22
49	D-22	D-22
50	D-23	D- 1

MESSAGE NUMBER	SIGN 1	SIGN 2
51	D- 1	D-23
52	D-23	D-23
53	D-24	D-24
54	D-25	D- 1
55	D- 1	D-25
56	D-25	D-25
57	D-26	D- 1
58	D- 1	D-26
59	D-26	D-26
60	D-27	D-27
61	D-28	D- 1
62	D- 1	D-28
63	D-28	D-28
64	D-29	D- 1
65	D- 1	D-29
66	D-29	D-29
67	D-30	D- 0
68	D-31	D- 0
69	D-32	D- 0
70	D-33	D- 0

SHEET 2 OF 3

CHANGEABLE MESSAGE SIGNS
DISPATCHER'S GUIDE

ACCIDENT--ALL LANES BLOCKED

Message Number	Sign 1	Sign 2	Message Number	Sign 1	Sign 2	Message Number	Sign 1	Sign 2
71	D-34	D-34	91	D-42	D-42	111	D-49	D-49
72	D-34	D- 6	92	D-42	D- 6	112	D-49	D- 1
73	D-35	D- 1	93	D-43	D- 1	113	D- 1	D-50
74	D- 1	D-35	94	D- 1	D-43	114	D-50	D-50
75	D-35	D-35	95	D-43	D-43	115	D-51	D-51
76	D-36	D-36	96	D-44	D-44	116	D-51	D- 1
77	D-36	D- 6	97	D-44	D- 6	117	D- 1	D-52
78	D-37	D- 1	98	D-45	D- 1	118	D-52	D-52
79	D- 1	D-37	99	D- 1	D-45	119	D-53	D- 0
80	D-37	D-37	100	D-45	D-45	120	D-54	D- 0
81	D-38	D-38	101	D-46	D-46			
82	D-38	D- 6	102	D-46	D- 6			
83	D-39	D- 1	103	D-47	D- 1			
84	D- 1	D-39	104	D- 1	D-47			
85	D-39	D-39	105	D-47	D-47			
86	D-40	D-40	106	D-48	D-48			
87	D-40	D- 6	107	D-48	D- 6			
88	D-41	D- 1	108	D-48	D- 1			
89	D- 1	D-41	109	D- 1	D-48			
90	D-41	D-41	110	D- 0	D- 0			

SHEET 3 OF 3

ATTACHMENT D

MESSAGE DISPLAY PROCEDURE

To Display Messages

1. Turn teletype switch to "LINE" position
2. Call Sign 1 (924-3822)
3. Listen for tone
4. Connect telephone receiver (MAKE SURE GREEN LIGHT IS ON)
5. Press "RETURN" button
6. Press "D" button and number for Sign 1 (see Dispatcher's Guide)
7. Press "RETURN"
8. Press "T"
9. Press "RETURN"
10. Wait until printer stops
11. Press "RETURN"
12. Disconnect receiver
13. Hang up phone
14. Call Sign 2 (924-3602)
15. Listen for tone
16. Connect telephone receiver (MAKE SURE GREEN LIGHT IS ON)
17. Press "RETURN"
18. Press "D" button and number for Sign 2 (see Dispatcher's Guide)
19. Press "RETURN"
20. Press "T"
21. Press "RETURN"
22. Wait until printer stops
23. Press "RETURN"
24. Disconnect receiver
25. Hang up phone
26. Turn teletype switch to "OFF".

To Turn Signs Off

1. Turn teletype switch to "LINE" position
2. Call Sign 1 (924-3822)
3. Listen for tone
4. Connect telephone receiver (MAKE SURE GREEN LIGHT IS ON)
5. Press "RETURN" button
6. Press "D" button and "Ø" button
7. Press "RETURN"
8. Press "T"
9. Press "RETURN"
10. Wait until printer stops
11. Press "RETURN"
12. Disconnect telephone receiver
13. Hang up phone
14. Call Sign 2 (924-3602)
15. Listen for tone
16. Connect telepohone receiver (MAKE SURE GREEN LIGHT IS ON)
17. Press "RETURN" button
18. Press "D" button and "Ø" button
19. Press "RETURN"
20. Press "T"
21. Press "RETURN"
22. Wait until printer stops
23. Press "RETURN"
24. Disconnect telephone receiver
25. Hang up phone
26. Turn teletype switch to "OFF" position

APPENDIX H

SOME EFFECTS OF BOTTLENECKS

Consider a section of freeway as shown in Figure 47. Assuming similar geometrics, the volume-density relationship at locations A and B are similar and can be represented by the upper curve in Figure 48. The highpoint on the curve represents the average maximum volume (or capacity). If a lane-blocking incident occurs at A, then the relationship at A would be similar to the lower curve in Figure 48.

Figure 48 also illustrates the effects of the incident. As long as the traffic demand at B is less than the bottleneck capacity at A, no significant congestion will occur. However, as the demand increases from 1 to 2, the traffic density at the bottleneck increases much more rapidly than that upstream. As the traffic demand rises to 3, the speed at the bottleneck drops rapidly and the flow is limited to the maximum volume on the lower curve. If more traffic arrives, it accumulates and forms a queue that propagates upstream. As the queue passes freeway location B, the conditions at B rapidly change from Y to Z. This change can happen quite suddenly and it involves an abrupt drop in speed and rise in traffic density with little change in flow (volume). The freeway at B will then operate in a manner depicted by the right side of the upper curve in Figure 48--high density and low volumes. As the traffic demand continues to be greater than the bottleneck capacity, the congestion will continue to propagate upstream from B.

Congestion represents the storage of vehicles on the freeway caused when demand exceeds the capacity (i.e., when more vehicles attempt to use the freeway than can be accommodated). Vehicle storage is illustrated by Figures 49 and 50. Figure 49 shows the superimposed input rate (approaching traffic demand) and output rate (satisfied demand) of a typical freeway section. If vehicles enter the system at a rate $i(t)$ and leave at a rate $o(t)$, they are being accumulated or stored in the freeway section at a rate $s(t)=i(t)-o(t)$. The vertical distance between the curves is the storage rate, $s(t)$. For the time period t_0 to t_1, the storage rate is positive. During this period the number of vehicles in the freeway section increases at the rate $s(t)$. At t_1, the freeway demand drops below the bottleneck capacity. From t_1 to t_2 the queued vehicles are clearing from the section and congestion is dissipating, during which the storage rate is negative.

The effects of traffic demands exceeding the bottleneck capacity is further illustrated in Figure 50. Note that congestion lasts from t_0 to t_2 and motorists entering the freeway section during this time experience delay. If, during this time, we were to observe a motorist entering one of the on-ramps of the freeway section shown in Figure 47 and destined to leave the freeway at the exit ramp, his normal progress will be delayed by the backup. He will not arrive at the ramp during the same time frame as usual. Prior to t_0 and after t_2, motorists entering the freeway are not delayed.

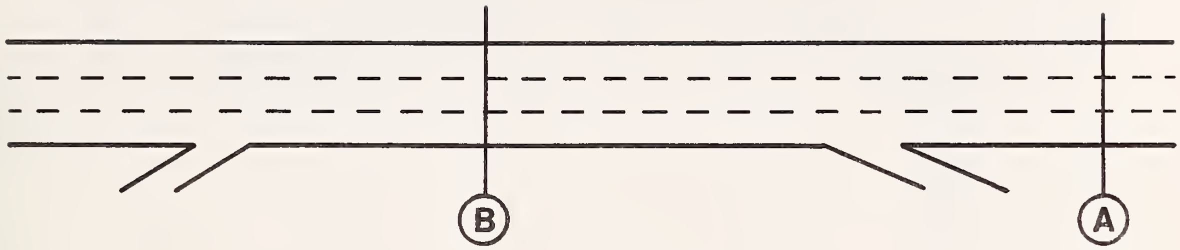


Figure 47 - Schematic of Freeway Section

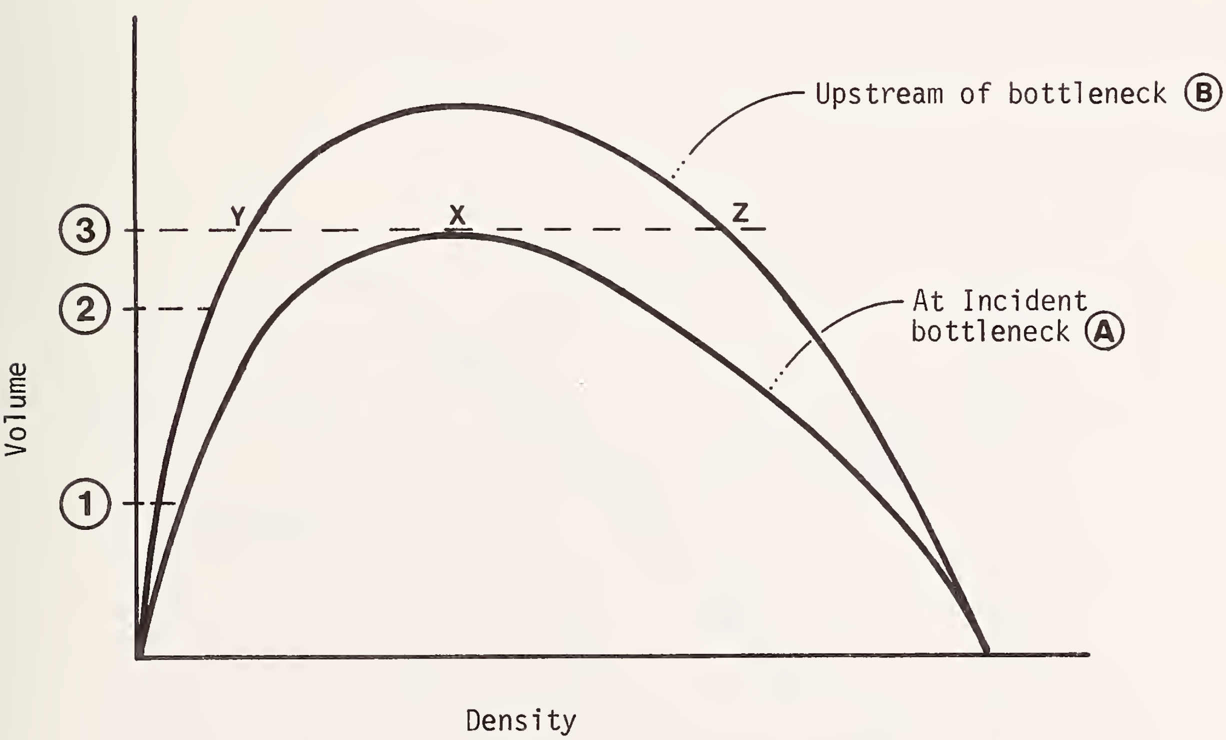


Figure 48 - Traffic Behavior Near a Bottleneck

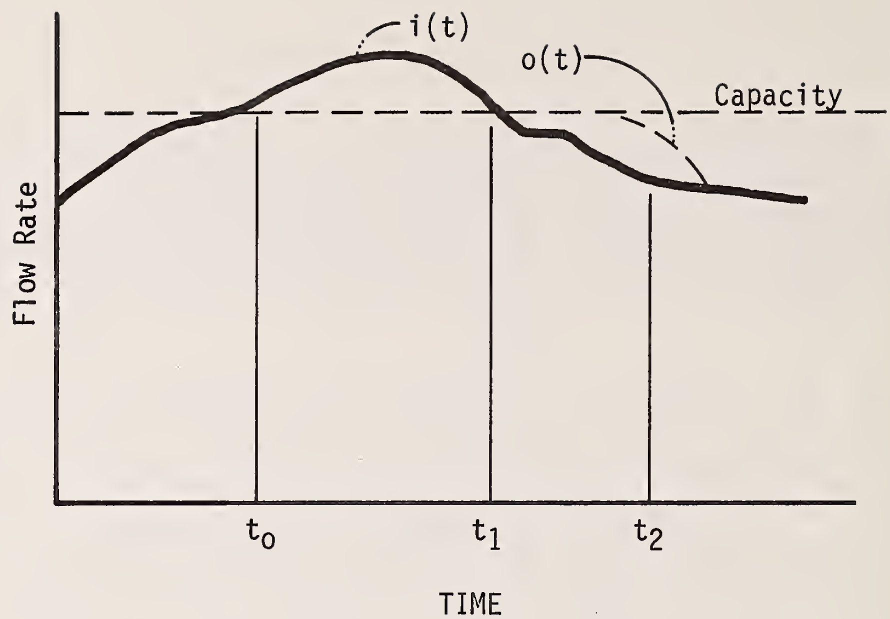


Figure 49 - Input-Output Rate Versus Time

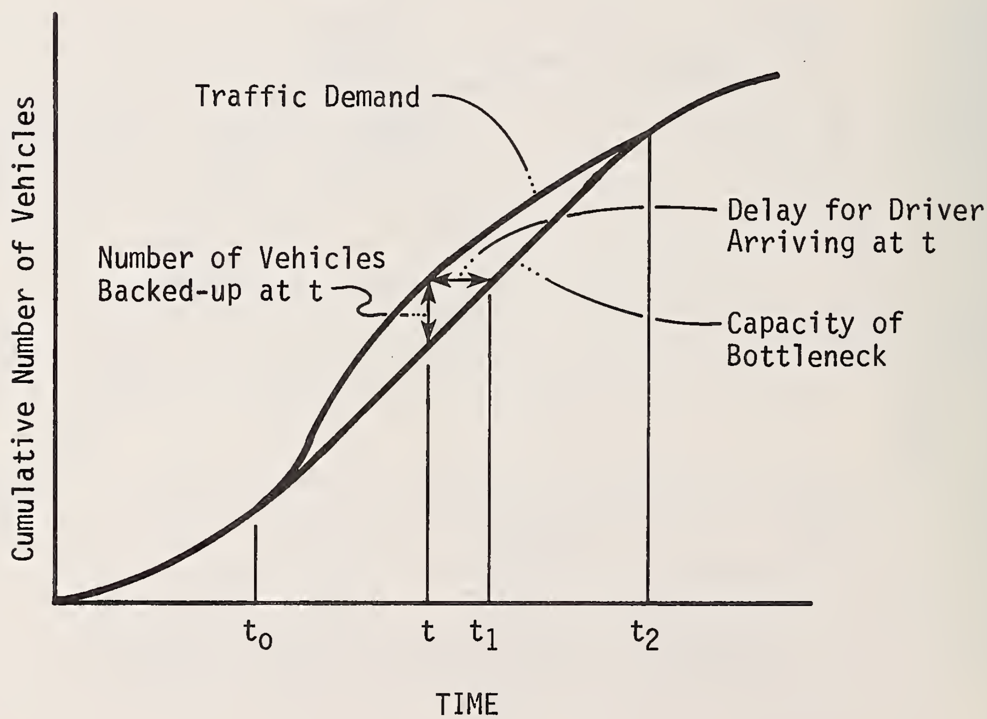


Figure 50 - Storage of Vehicles on a Freeway

The important point of this discussion is that true demand for the exit ramp can only be measured by beginning the analysis period at or before t_0 (i.e., when there is no traffic buildup) and extending the analysis until at least t_2 (i.e., when the back-up or congestion dissipates). A shorter analysis period would result in an assessment of the number of drivers who actually use the ramp during this time period, and not those who wanted (demand) to use it, but were delayed and stored in the freeway backup.

INCIDENT CASE STUDIES

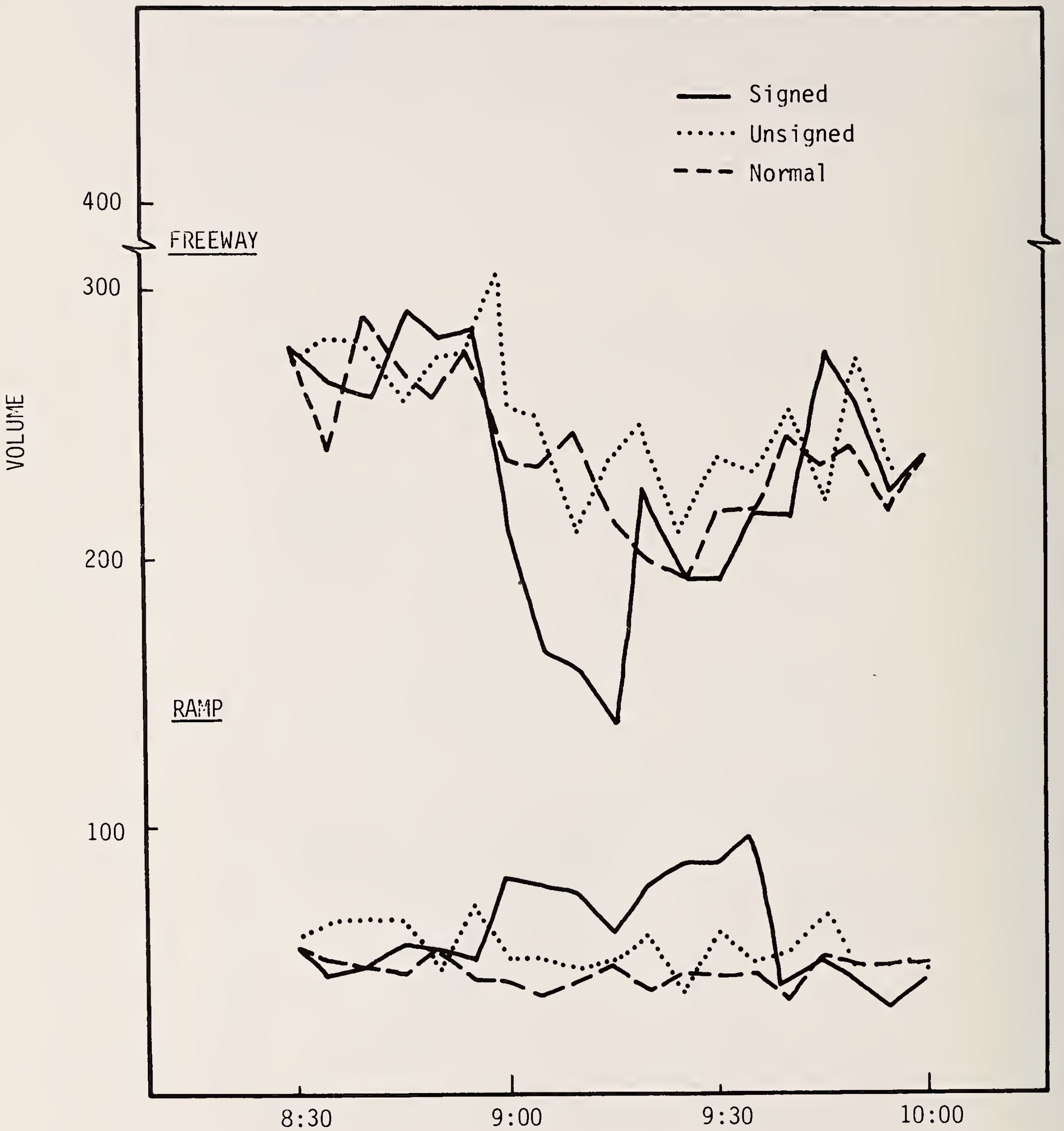


Figure 51 - Incident Case Study 1

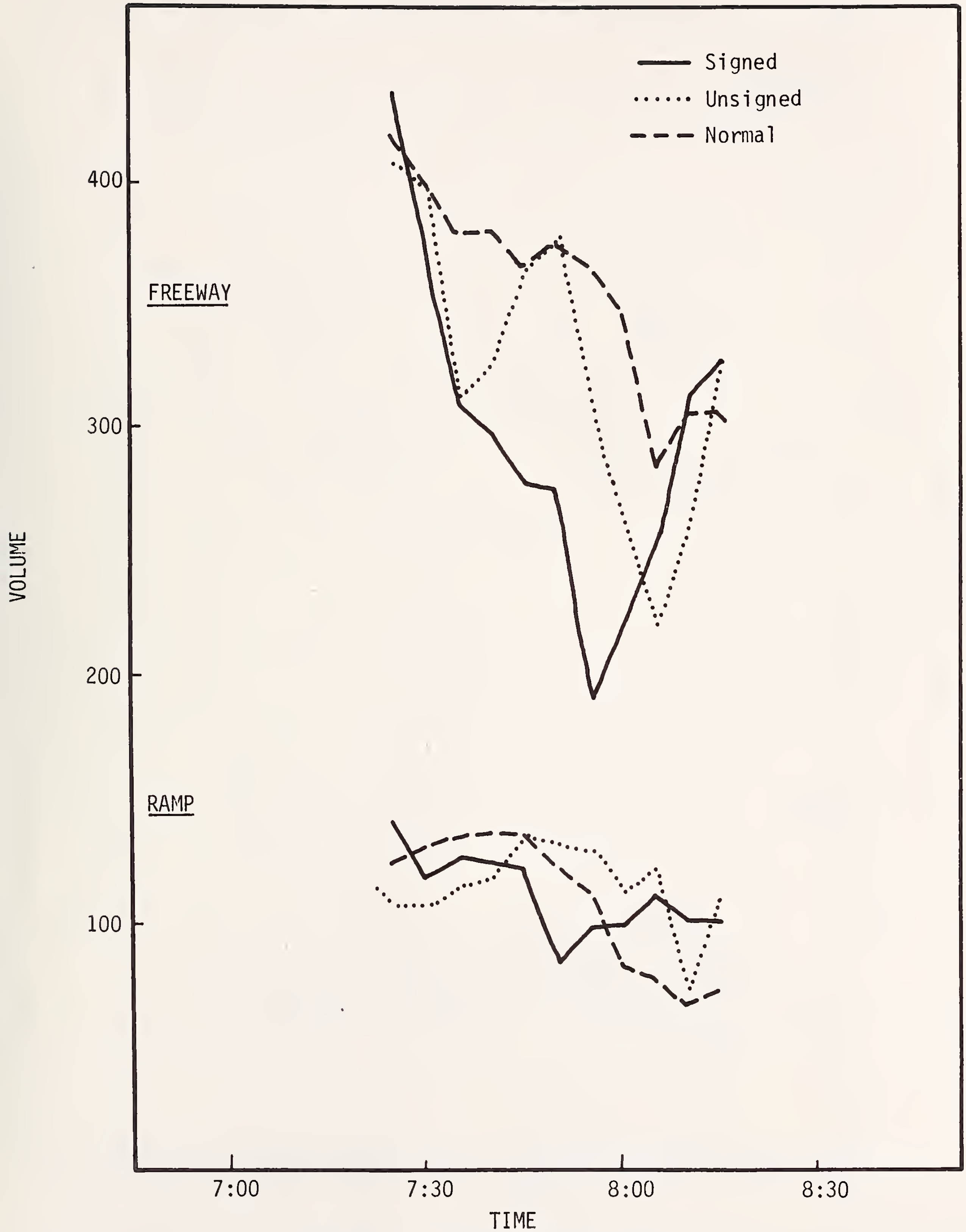


Figure 52 - Incident Case Study 2

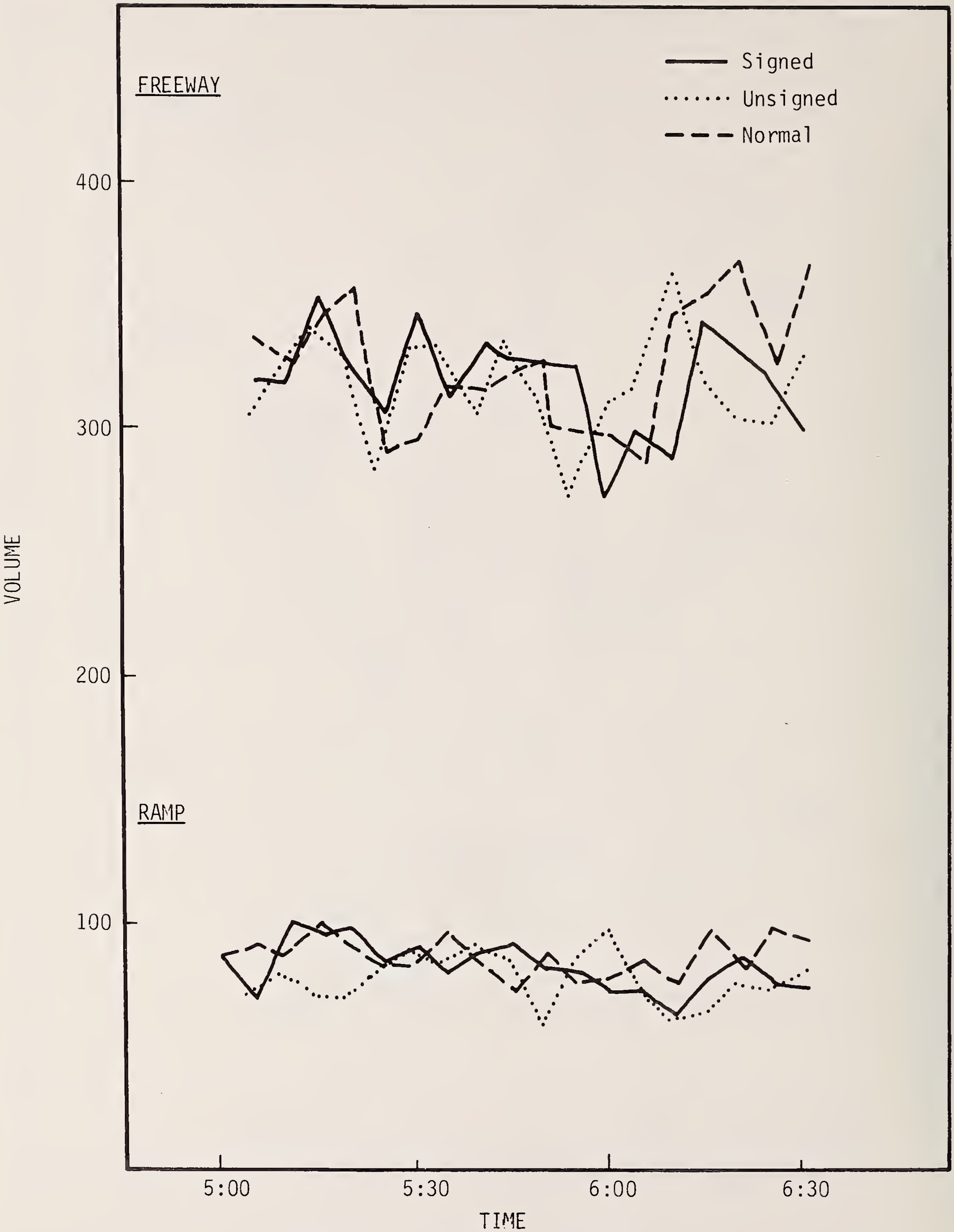


Figure 53 - Incident Case Study 3

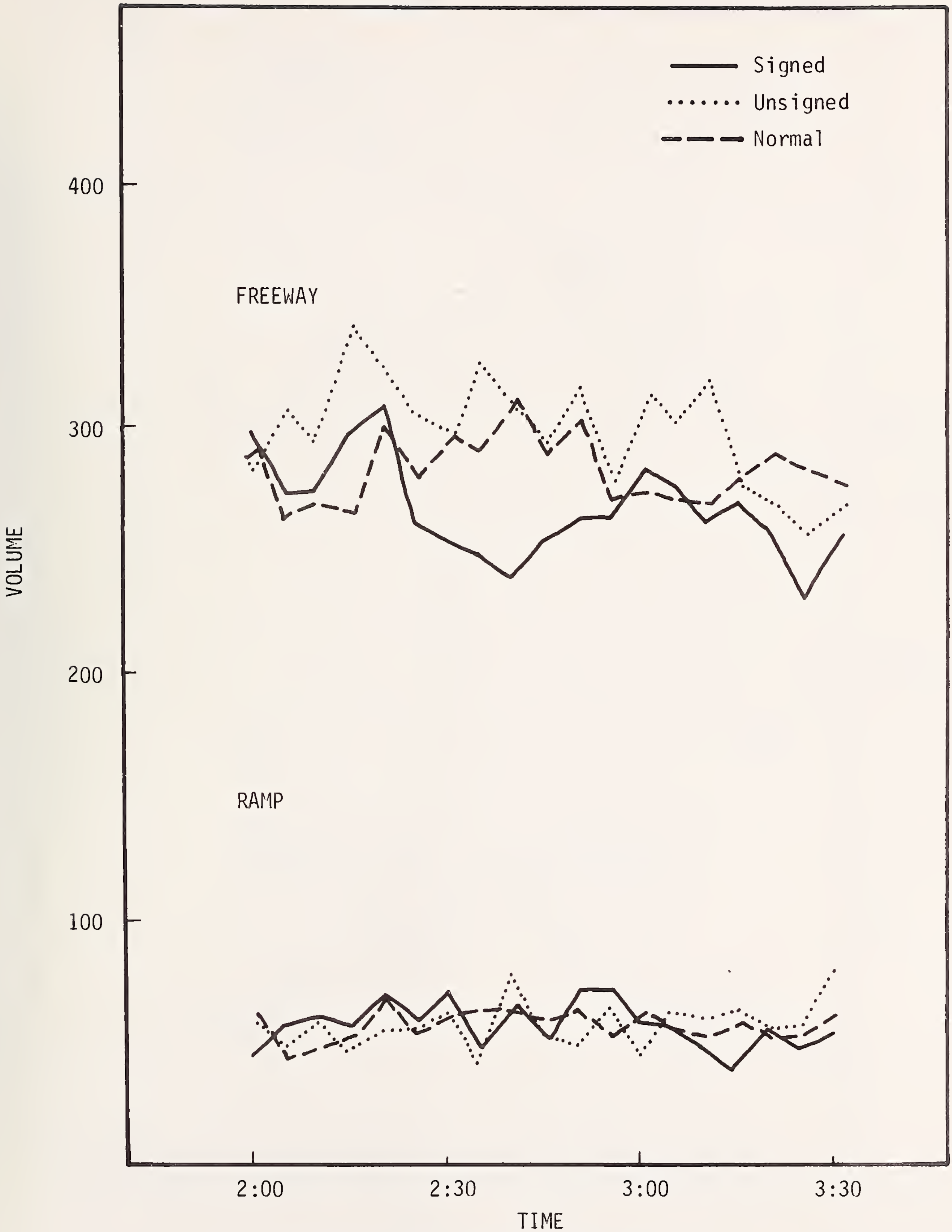


Figure 54 - Incident Case Study 4

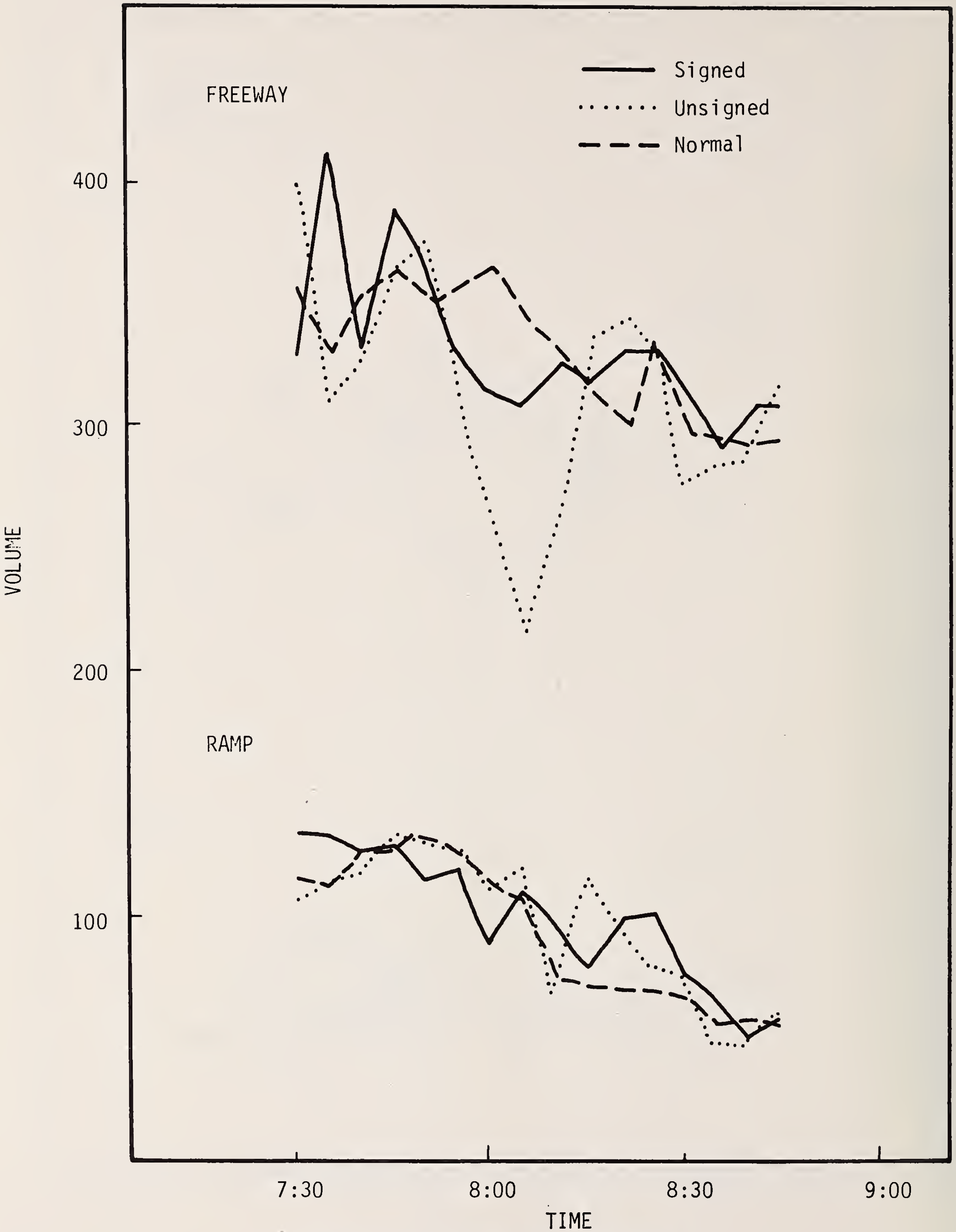


Figure 55 - Incident Case Study 6

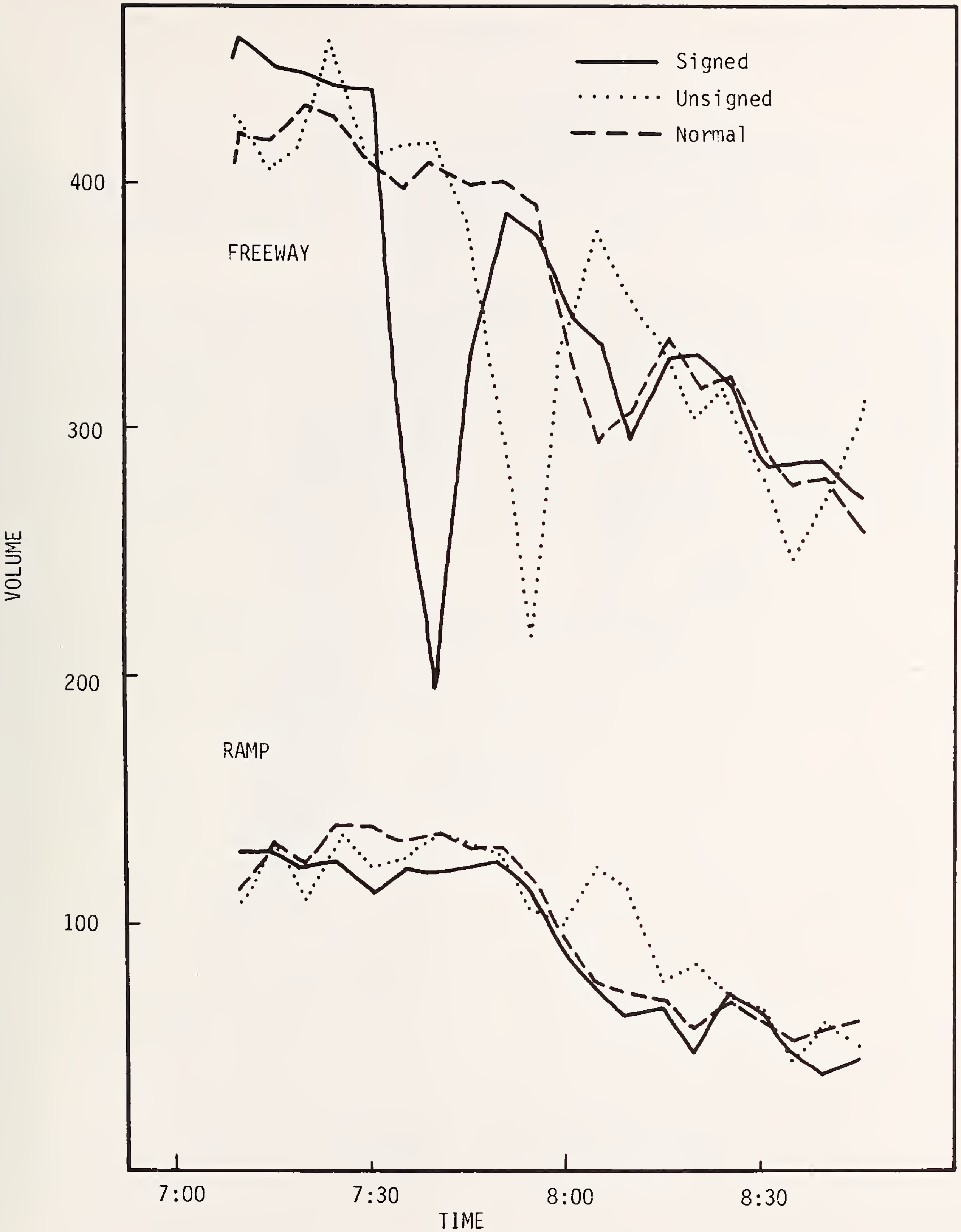


Figure 56 - Incident Case Study 7

APPENDIX J

REVISED MESSAGE GUIDE

As discussed in previous Chapters, one problem was that the patrol officers and dispatchers were experiencing difficulty in efficiently operating the CMS system because of two factors: unfamiliarity with hardware, and the extremely heavy workload in the normal process of taking care of the accident itself.

In an attempt to reduce dispatcher workload and improve performance, consideration was given to condensing incident location information to reduce the number of messages. Basically only two categories of incident locations exist--those where diversion is practical (north of I-10E/US-90W) and those where diversion is not practical (south of I-10E/US-90W). All diversion-related messages were therefore consolidated by eliminating any reference to incident location. Similar changes were made to all non-diversion messages. The resulting set of messages is shown in an abbreviated, operator-oriented form in Figure 57. The basic texts of the messages were not changed other than eliminating references to locations.

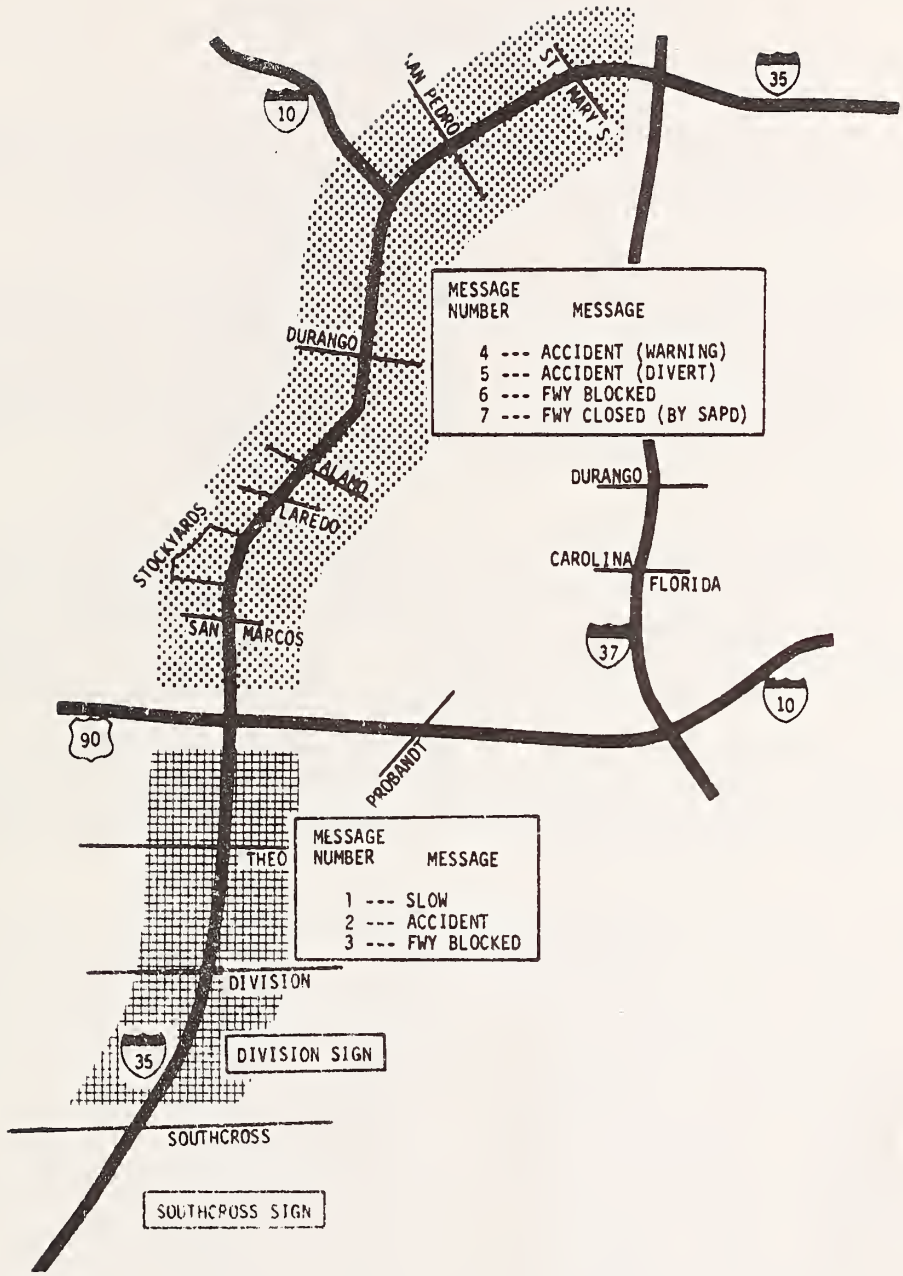


Figure 57 - A Revised and Abbreviated Message Selection Guide Keyed to Incident Location

APPENDIX K

LICENSE PLATE SURVEY ACCURACY
A CASE STUDY

Because of the concern about the accuracy of the nighttime license plate O-D studies, a supplementary study was conducted to determine how well the technique and the computer license plate matching program worked.

License plate data from the March 17 and 18, 1980 studies were matched manually. Care was exercized in matching obvious reading and interpretation errors. For example, RDX 899 read at the I-35 input station, may have been incorrectly read as RBX 899 at one of the output stations. By using normal travel time information and scrutinizing the data to recognize license numbers of other vehicles traveling the same route about the same time, it was easy (but time consuming) to make the appropriate matches manually.

Table 25 summarizes the results of the analysis. The number of license plate matches between the origin (I-35 at Theo) and three primary destinations (I-35 at St. Mary's, I-10E/I-37 ramp, and I-35/I-10W ramp) is shown for the manual approach and a computer matching routine (i.e., the number of matches that would have been noted by the computer). Also shown is the percent of matches that would have been missed (errors) by the computer approach.

The data show that the percent of vehicles that would have been missed by the computer program (errors) ranged between 23% and 45%. The percent error for the March 17th study averaged 31% while on March 18, averaged 35%. The average across both days was 34%.

Although the study was conducted at night, there is reason to believe that comparable errors will occur during daytime license plate O-D studies. Most of the vehicles that the computer program would have failed to match resulted from interpretation errors of similar sounding letters from the cassette tapes, errors in the field when observers interchanged numbers or letters, or when they simply did not read the plate correctly. All three problems are affected by the requirement to read license plates of high-speed, high-volume traffic. The first problem is also affected by the quality of the observers' speaking voices. Lighting conditions on the freeway and on the interchange ramps during the San Antonio studies seemed to be sufficient, and vehicle lighting on the license plates in most cases seemed to be adequate. Therefore, it appears that license plate O-D data recorded on freeways and high-speed interchange ramps during the day will result in errors comparable to those reported herein.

TABLE 25

COMPARISON OF MANUAL AND COMPUTER
LICENSE PLATE MATCHINGS

Destination Station	March 17, 1980			March 18, 1980			Percent Errors Both Days
	Number of Manual Matches	Number of Computer Matches	Percent of Matches Missed by Computer (Errors)	Number of Manual Matches	Number of Computer Matches	Percent of Matches Missed by Computer (Errors)	
I-35 at St. Mary's	99	76	23	65	36	45	32
I-10/I-37N Ramp	49	27	45	81	57	30	35
I-35/I-10W Ramp	37	25	32	209	138	34	34
TOTAL	185	128	31	355	231	35	34

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FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

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